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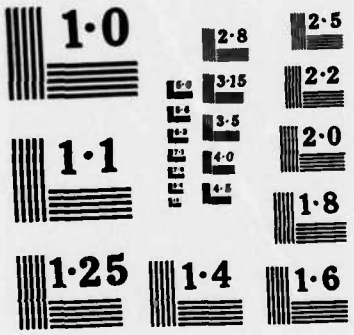

REPORT NO. 1-85

DEVELOPMENT OF A DECOMPRESSION ALGORITHM FOR CONSTANT 0.7 ATA OXYGEN PARTIAL PRESSURE IN HELIUM DIVING

By:

Edward D. Thalmann, CDR, MC, USN

April 1985

NAVY EXPERIMENTAL DIVING UNIT

DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407

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COMPUTER MODEL	HELIUM DIVING	MK 16 UBA
CONSTANT OXYGEN PARTIAL PRESSURE	HELIUM SCUBA	WORKUP PHENOMENON
DECOMPRESSION MODEL	HELIUM TABLES	
DECOMPRESSION SICKNESS	MATHEMATICAL MODEL	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A total of 1582 man dives were done to test a computer algorithm used to compute decompression schedules for a closed circuit underwater breathing apparatus which maintains a constant 0.7 ATA PO_2 in a helium diluent. The 47 test dives were all single depth dives up to 300 FSW deep with total dive times approaching 4 hours. The first three phases of testing resulted in a computer algorithm which appeared initially safe but which subsequently

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produced an unacceptably high incidence of decompression sickness (DCS) on a later dive series. Investigation of this high incidence of DCS on later dives lead to the identification of a workup phenomenon which showed that previous HeO_2 diving will significantly reduce individual susceptibility to DCS. Further testing resulted in a computer algorithm which would compute safe decompression schedules for divers who are not worked up. The overall raw incidence of DCS for the entire dive series was 3.73% with 37% of all symptoms being Type 2. The overall incidence of DCS was 3% lower than that found during testing of a similar computer algorithm using a constant 0.7 ATA PO_2 and a nitrogen diluent but the proportion of Type 2 DCS was higher using a helium diluent than when using a nitrogen diluent. Complete details of the computer algorithm, all decompression schedules tested, and complete sets of the final decompression tables are given in the 8 appendices to this report. Complete clinical descriptions of all cases of DCS as well as treatment results are given. The pertinence of the final decompression model to current HeO_2 bounce and saturation diving is also discussed.

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ABSTRACT

A total of 1582 man dives were done to test a computer algorithm used to compute decompression schedules for a closed circuit underwater breathing apparatus which maintains a constant 0.7 ATA PO_2 in a helium diluent. The 47 test dives were all single depth dives up to 300 FSW deep with total dive times approaching 4 hours. The first three phases of testing resulted in a computer algorithm which appeared initially safe but which subsequently produced an unacceptably high incidence of decompression sickness (DCS) on a later dive series. Investigation of this high incidence of DCS on later dives lead to the identification of a workup phenomenon which showed that previous HeO_2 diving will significantly reduce individual susceptibility to DCS. Further testing resulted in a computer algorithm which would compute safe decompression schedules for divers who are not worked up. The overall raw incidence of DCS for the entire dive series was 3.73% with 37% of all symptoms being Type 2. The overall incidence of DCS was 3% lower than that found during testing of a similar computer algorithm using a constant 0.7 ATA PO_2 and a nitrogen diluent but the proportion of Type 2 DCS was higher using a helium diluent than when using a nitrogen diluent. Complete details of the computer algorithm, all decompression schedules tested, and complete sets of the final decompression tables are given in the 8 appendices to this report. Complete clinical descriptions of all cases of DCS as well as treatment results are given. The pertinence of the final decompression model to current HeO_2 bounce and saturation diving is also discussed.

KEY WORDS:

COMPUTER ALGORITHM
COMPUTER MODEL
CONSTANT OXYGEN PARTIAL PRESSURE
DECOMPRESSION MODEL
DECOMPRESSION SICKNESS
DECOMPRESSION TABLES
HELIUM DIVING
HELIUM SCUBA
HELIUM TABLES
MATHEMATICAL MODEL
MK 15 UBA
MK 16 UBA
WORKUP PHENOMENON

NEDU TEST PLAN NUMBERS: 82/01; 82/14; 82/36; 83/39; 84/13

GLOSSARY

Actual Dive Profile - A table or graph showing the actual depth/time coordinates for an entire dive.

Algorithm - A sequence of logical steps used to obtain a mathematical result.

Ascent Criteria - A set of constraints on a decompression model which defines how ascent may be accomplished without causing decompression sickness.

Bottom Time - The elapsed time from leaving the surface until beginning ascent to the first decompression stop (or the surface if a no-decompression dive).

Computer Program - A series of instructions directing a computer how to process information to obtain the desired output. A computer program may contain one or more algorithms which perform intermediate calculations. As an example, a computer program for an Underwater Decompression Computer (UDC) may contain algorithms describing gas uptake and elimination, rules for finding the first stop and warning the diver when he is outside of the tested limits.

Decompression Model - A series of algorithms which describe how gas is taken up and given off by the body during a dive and what conditions must be met in order to avoid decompression sickness.

Decompression Obligation - The total amount of decompression stop time accrued at any time in a dive profile if ascent were begun at that instant at a specified rate.

Decompression Profile - A table or graph showing the depth-time coordinates for an entire dive including all desired stops and all obligatory decompression stops.

Decompression Schedule - A listing showing required decompression stop depths and stop times for a particular bottom depth/time dive at specified ascent and descent rates.

Decompression Table - A structured set of decompression schedules usually organized in order of increasing bottom depths and bottom times.

Dive Profile - A table or graph of depth/time coordinates for an entire dive showing all desired stops without regard to decompression obligation.

EL-MK 15/16 Decompression Computer Algorithm (DCA) - A computer program using the EL-MK 15/16 Decompression Model which will print out decompression profiles or tables given a dive profile.

EL-MK 15/16 Decompression Model (DCM) - The particular series of algorithms which describe the assumptions used in computing decompression profiles or tables for use with the closed circuit 0.7 ATA constant PO_2 underwater breathing apparatus.

EL-MK 15/16 Real Time Algorithm (RTA) - A computer program using the EL-MK 15/16 Decompression Model which will compute and update Safe Ascent Depth in real time given a continuous input of actual depth.

MPTT -Maximum Permissible Tissue Tension. The maximum tension which can be present in any tissue at a given depth such that decompression sickness will not occur.

No-Decompression Time (No-D Time) - The maximum time which can be spent at a given depth (including descent time at a specified rate) such that ascent can be made directly to the surface at a prescribed rate.

SAD -Safe Ascent Depth. The shallowest depth which could be ascended to at any tme in a dive profile without violating the ascent criteria. The SAD is used in real time decompression profile execution and is computed and displayed by the EL-MK 15/16 RTA.

SDR -Saturation-Desaturation Ratio. The ratio of the theoretical tissue halftime used to compute gas uptake to the halftime used to compute gas elimination.

Set Point -The PO_2 in a closed circuit UBA at which oxygen is added to the breathing loop.

Theoretical Halftime Tissue - A conceptual area of body tissue whose gas uptake can be described by an exponential term with a time constant K or halftime equal to ln(2)/K.

Development of a Computer Algorithm for Constant 0.7 ATA Oxygen Partial Pressure in Helium Diving

By: Edward D. Thalmann, CDR, MC, USN

INTRODUCTION

Several years ago, the Explosive Ordnance Disposal (EOD) Community undertook the development of a new Underwater Breathing Apparatus (UBA) to replace the aging MK 6 UBA. The result of this development was the MK 16 UBA which electronically controls the oxygen partial pressure (PO_2) to a predetermined level independent of depth. Functionally, the MK 16 is almost identical to the MK 15 UBA; the main difference being that the MK 16 has a low magnetic and acoustic signature necessary for the EOD environment (1,1a). Both the MK 15 and MK 16 can use either a nitrogen or helium diluent depending on the type of diving being done. Previous studies at NEDU have described the development of a computer algorithm for computing constant 0.7 ATA PO_2 decompression tables using a nitrogen diluent (3,4). This computer algorithm also served as the basis for a computer program for a small wrist-worn Underwater Decompression Computer (UDC) which would compute decompression obligation in real time for a 0.7 ATA constant PO_2 in N_2 breathing gas as a dive was being conducted (4).

The purpose of the present study was to develop a computer algorithm which could be used to compute a set of decompression tables using helium as a diluent and also be programmed into a UDC, if desired. Since the EOD mission does not require complex multiple level dives this study looked only at single depth dives (square dives). In addition, since the MK 15 and MK 16 are functionally similar and both control the PO_2 in the same way (1,1a,2,2a), dives were done using the MK 15 UBA, the MK 16 not being available at the time of the study. However, the decompression algorithm developed in this study are applicable to either the MK 15 or MK 16 as long as the set point is 0.7 ATA and the appropriate diluent is used.

In addition to testing square dive decompression schedules, an emergency procedure for use in operational diving whereby a diver breathing an HeO_2 mix on the bottom breathed air during decompression was tested. This would allow surface-supplied air SCUBA supplied via a HOOKA to be used in the event of a UBA failure during decompression.

This report is intended to be both encyclopedic and archival and as such may seem overdetailed in parts. As much information as possible was included covering all facets of the dive series. The intent was that future investigators should find any information they may need for future analysis in this report minimizing the need to consult original data sources. In addition, reasons for all changes in analysis or methods are given even if the decisions were arbitrary to minimize future conjecture.

METHODS

General

All 174 divers who participated in this study were active duty Navy or Army divers, or military trained civilians. Divers from the U.S., Canadian and British military participated. The physical characteristics of all divers is given in Appendix A. One of the divers (#134) was a female. There were 5 separate dive series (Phases I, II, III, IV and V) and some subjects participated in more than one phase. Divers were all actively exercising up to the time of their particpation in the study and were all in good physical condition. All divers were given thorough diving physical examinations before each dive series began and were examined immediately before and after each dive by a U.S. Navy Diving Medical Officer. Physical characteristics for all divers are found in Appendix A.

All divers were thoroughly trained in the use of the MK 15 closed-circuit constant PO_2 UBA and all dives were done using the MK 15 UBA with the PO_2 setpoint adjusted to 0.7 ATA. A complete description of the MK 15 hardware and operating characteristics is given in references (2) and (2a). With a PO_2 setpoint of 0.7 ATA, the MK 15 will automatically add oxygen when the PO_2 falls to 0.7 ATA. Normally, the PO_2 will have a mean level between 0.7 ATA and 0.8 ATA, but could be as low as 0.6 ATA without the UBA indicating a malfunction. This PO_2 range is maintained irrespective of depth. There is an alarm light that will warn a diver if his PO_2 falls to 0.6 ATA. If this happened during dives in this study, the diver was instructed to manually add oxygen and to change to another UBA if PO_2 could not be maintained automatically in the 0.6-0.8 ATA range. As long as no alarm lights indicated a low PO_2, divers were instructed to let the UBA control automatically and no attempt was made to control the PO_2 at exactly 0.7 ATA. As will be seen later, this means that the tables resulting from this dive series could be used with any UBA which uses a helium diluent and which controls to a mean PO_2 of 0.7 ATA (or greater) as long as it warns the diver when the PO_2 falls to 0.6 ATA. As will be seen, the final version of the MK 16, which is the UBA which will be primarily used with the tables, has a set point of 0.75 ATA and warns the diver when the PO_2 falls below 0.6 ATA.

The diluent used for all dives in this series was 100% helium. Operationally a HeO_2 mix will be used which would result initially in higher oxygen partial pressures immediately after compression as diluent gas is added to the breathing loop to make up volume. By using 100% helium the oxygen partial pressure during the first portion of time at depth will be lower than it will be when operational dives take place. Since a lower PO_2 is presumed to increase decompression obligation, tables were developed under conditions of maximum decompression stress with respect to oxygen partial pressure.

All dives were conducted in the 15 foot diameter by 46 foot long wet chamber of the Ocean Simulation Facility (OSF) at the Navy Experimental Diving Unit (NEDU) in Panama City, Florida. Divers were generally divided into 10 man teams. While at depth the 10 divers performed intermittent exercise at 75 watts on an electrically braked bicycle ergometer pedalling at 55-60 RPM.

Since only 5 bicycle ergometers were available, only half the divers were actually exercising at a given time. Exercise periods lasted 6 minutes at which time the 5 non-exercising divers mounted the ergometers and began exercising. This alternating 6 minute work, 6 minute rest cycle continued until 1 minute prior to decompression at which time all exercise stopped.[1] Previous studies showed that the mean oxygen consumption for divers in wetsuits pedalling 55-60 RPM doing this alternating work/rest cycle was approximately 1.00-1.2 ℓ/min with a 1.6-1.8 ℓ/min oxygen consumption during exercise and a 0.4-0.5 ℓ/min oxygen consumption at rest (1,14)[2]. All divers remained at rest for the entire decompression. During dives where air was used for decompression, divers came off of the MK 15 UBAs and breathed air from standard open circuit SCUBA regulators.

All dives were done using a decompression schedule generated in real time by a Hewlett-Packard HP 1000 Series Computer using an algorithm as described below. The computer continuously monitored chamber depth from an Ashcroft Digigauge to an accuracy of $\pm$ 1 FSW and updated the diver's decompression status every 2 seconds. Real time algorithms were developed as described elsewhere (5). Real time computation allowed any holds or changes in travel rate during ascent and/or descent to be taken into account thus producing a decompression schedule exactly suited to a particular dive profile. The decompression status was displayed on a video display as the shallowest depth which could be ascended to at any given time without violating the ascent criteria, the so-called Safe Ascent Depth (SAD). During decompression the divers' depth was matched to the SAD which was always computed in 10 FSW increments. The actual dive profiles were continuously recorded and stored by the computer and could be retrieved after the dive. A typical dive profile plot is shown in Figure 1.

Dives were accomplished as follows. Divers donned their UBAs outside of the chamber and breathed chamber air as they entered the water. After entering the water, all divers switched from breathing air to breathing from the MK 15 UBA at the end of a full inspiration and descended to the bottom of the wetpot in unison on signal from the Dive Supervisor, thus ensuring that computer updates regarding breathing gas changes and depth changes corresponded exactly to what the divers were doing in real time. Dive time began when the divers began breathing from the MK 15. Once at the bottom of the wetpot (a depth of 7 FSW to mid chest), all divers were instructed to remain upright with their feet just touching the floor of the wetpot. The bicycle ergometer frame heights were such that exercising and non-exercising divers were within 1 FSW depth of each other at mid chest. Thus, the assumed depth error over an entire dive was $\pm$ 1 FSW between divers.

[1] Some dives had bottom times too short for each team member to do a full 6-min exercise run. In these cases, each team member exercised for one-half of the available bottom time.

[2] NEDU Report 1-84 (4) mistakenly reported divers exercising 10 min at 50 watts. In fact, the exercise protocol for the N_2O_2 dives (4) was exactly the same as done in this study.

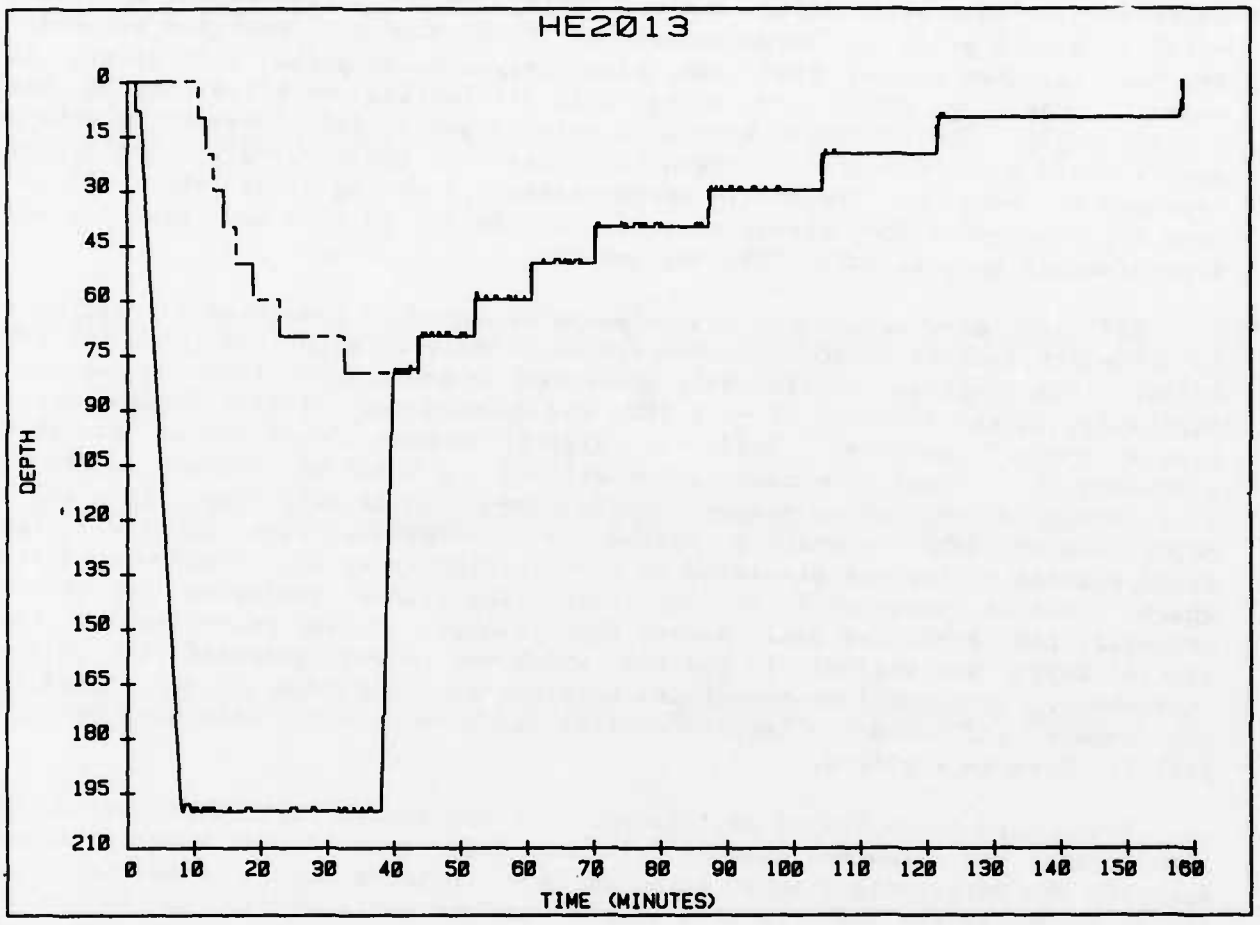

FIGURE 1. Typical Dive Profile. The actual depth is the solid line and the computer generated Safe Ascent Depth (SAD) is the broken line. HE2013 is the computer file name signifying the 13th dive of Phase II. This is an HVAL07 schedule to 200 FSW with a 120 min total decompression time. This profile was designated as a 200/30 schedule but the total decompression time actually puts it somewhere between 200/30 and 200/35. (See Appendix H).

Descent rates were 30-60 FSW/min depending on diver's ability to clear their ears. In some cases there were holds on the way down followed by intermittent ascents because of eustachian tube blockage in some divers. Since the decompression schedules were all computed in real time all these holds were taken into account in determining actual decompression obligation. Ascent rates were 60 FSW/min to 20 FSW, 40 FSW/min to 10 FSW, and 30 FSW/min from 10 FSW to the surface, these being the maximum OSF wet chamber travel rates over these depth ranges.

The wet chamber was pressurized with HeO_2 only during Phase I and with air for all other phases. Occasionally, a diver would have to come off of his UBA while at depth because of a rig malfunction. A dry underwater refuge was in the wetpot and always contained an HeO_2 atmosphere. The PO_2 of the refuge was close to but not always exactly 0.7 ATA and contained no nitrogen. If a diver had to breathe refuge atmosphere for more than a few minutes he was eliminated as a test subject from that particular dive. Chamber occupants (tenders or divers withdrawn from the wetpot) always breathed an HeO_2 mix with a PO_2 much greater than 0.7 ATA by mask (6-10). As previously mentioned, no effort was made to regulate PO_2 as long as the MK 15 was controlling the PO_2 normally, that is between 0.6 and 0.8 ATA. If a diver found his PO_2 outside of this range (as indicated on the MK 15 secondary display), he first adjusted the PO_2 manually to 0.7 ATA. If the UBA still failed to properly control the PO_2, the diver was immediately given another UBA.

The only criteria used to evaluate the safety of a paticular dive profile was the occurrence of clinical decompression sickness. The determination as to whether or not a particular diver had decompression sickness was made by an experienced U.S. Navy Diving Medical Officer who evaluated both subjective and objective signs and symptoms. If, in the opinion of the examining Diving Medical Officer (based on diver history and physical examination), decompression sickness was present, then appropriate treatment was instituted. No other criteria (such as ultrasonic doppler monitoring) were used to determine whether or not decompression sickness was present. Usually symptoms of decompression sickness would not manifest themselves until the diver surfaced in which case only the stricken diver was treated. In some instances symptoms occurred while still at depth and when the stricken diver could not be isolated in another chamber all the other divers on that particular dive were treated along with the stricken diver. In these cases, the asymptomatic divers were not included in the dive statistics at all while the stricken diver was counted as a case of decompression sickness. All treatments for decompression sickness were done using standard U.S. Navy Oxygen Treatment Tables unless otherwise noted.

Each of the MK 15 UBAs had a gas sample line on the CO2 absorbant canister effluent side. During rest periods divers would enter the underwater refuge and connect the UBA gas sample line to a snap fitting recepticle which piped the UBA gas sample to a mass spectrometer (MGA 1100 Perkin Elmer Co.) located outside of the chamber. This allowed periodic analysis of UBA O_2, CO_2, N_2 and He levels.

Water Temperatures, Inspired Carbon Dioxide:

Water temperature was adjusted to maximize thermal stress on the diver without causing dive aborts. Temperature was set ($\pm$ 2°F) according to the

total dive time as follows: 360 min or greater, 65°F; 359-190 min, 60°F; 189-80 min, 55°F; 79-30 min, 50°F; 29 min or less, 45°F. Total dive time was estimated before the dive and in actuality may have been several minutes longer or shorter than planned depending on the number of holds during ascent. All divers wore full 1/4" neoprene wetsuits consisting of "Farmer John" trousers, jacket, hood, gloves and boots. Most divers were visibly chilled and shivering when exiting from dives. The only exception to the above temperatures was during 47 man dives done at the end of Phase I testing which were done in 71°F water.

Inspired CO_2 tension was not allowed to rise above 7.6 mmHg as monitored on the mass spectrometer without having the diver switch to another MK 15 UBA. The usual range of CO_2 tension was 0-2 mmHg with the maximum values occurring after 4-5 hours during long 250 and 300 FSW dives. UBA gas sampling was not done during Phase IV and and Phase V because experience from Phase I-III showed that inspired CO_2 would not rise above 2 mmHg in a normally functioning UBA during the maximum anticipated total dive time (5 hrs).

Decompression Model and Computer Algorithms

The object of this study was not to test decompression tables but rather to develop and test a computer algorithm which could be used to compute a set of decompression tables. In doing the testing, depths and bottom times were chosen based on UBA maximum operational depth and time limits to define the depth-bottom time domain within which the computer algorithm would compute safe decompression schedules in real time. Once this depth-time domain was defined and manned testing had verified its safety, this computer algorithm would then be used to compute a set of decompression tables for any desired depth/bottom time combination within that domain. In addition, the same computer algorithm could be used to compute decompression schedules in real time using a suitable computer and depth monitor.

The decompression model is the set of assumptions describing the assumed physiology involved in gas uptake and elimination by the body during a dive as well as the criteria which must be met to avoid decompression sickness (also called ascent criteria). The decompression model used for this study is the Exponential-Linear (EL) version of the model used in developing the computer algorithm for 0.7 ATA constant PO_2 in N_2 diving and is thoroughly described elsewhere (ref. 4, Appendix A). This decompression model will be referred to as the Exponential-Linear MK 15/16 Decompression Model (EL-MK 15/16 DCM). While the decompression model actually encompasses all equations and assumptions necessary for avoidance of decompression sickness (DCS), reference to the EL-MK 15/16 DCM will refer mainly to that portion of the model describing gas uptake and elimination. The other portion of the model which defines the ascent criteria are found in the various Maximum Permissible Tissue Tension (MPTT) Tables which define the maximum gas tension allowed in any of the theoretical halftime tissues at a given depth. Thus, to compute a decompression schedule the EL-MK 15/16 DCM computes tissue tensions based on the desired dive profile then computes decompression stops such that no tissue exceeds its MPTT at any depth. The intent is that by never having any tissue exceed its MPTT, decompression sickness will be avoided.

In order to actually compute decompression tables and perform man dives the decompression model must be translated into a computer algorithm (or program) which will accept input and actually calculate a decompression schedule in real time or print out a set of decompression tables. The EL-MK 15/16 DCM served as the basis for two computer algorithms. The first was the EL-MK 15/16 Decompression Computer Algorithm (EL-MK 15/16 DCA) which was a computer program designed to accept as input sets of depth time coordinates and which would print out a decompression schedule for a profile of any degree of complexity (program DMDB7) or a complete set of decompression tables (program TBLP7). Both DMDB7 and TBLP7 are input/output programs and the decompression model is contained in the EL version of the 8 subroutines used by the programs. These two programs and the associated EL versions of the subroutines have been previously documented (5) and will be referred to collectively as the EL-MK 15/16 DCA.

Using the same EL-MK 15/16 DCM, a computer program was written which would compute decompression schedules in real time. This program is known as the EL-MK 15/16 Real Time Algorithm (EL-MK 15/16 RTA) and is described elsewhere (4). In the real time version, the EL-MK 15/16 DCM updates tissue tensions every 2 sec given the current depth as monitored by a digital depth gauge. It then computes the minimum depth which could be ascended to at any instant such that no tissue exceeds its MPTT, and displays the result as the Safe Ascent Depth (SAD). In doing this study, the optional warning status used in the N_2O_2 version of the EL-MK 15/16 RTA (4) was not implemented.

Both the EL-MK 15/16 DCA and RTA accepted the same set of ascent criteria in the form of MPTT Tables. The MPTT's in this study were designed specifically for a helium-oxygen breathing gas and a total of 13 different sets were used and are presented in Appendix E. These MPTT's specify the number and halftimes of the theoretical tissues to be used by the computer algorithms as well as the Saturation Desaturation Ratio (SDR). The SDR is the ratio of tissue halftimes used for computing gas uptake to that used for computing gas elimination. During computation of gas uptake (saturation) the tissue halftime as shown in the MPTT Table is used but during offgassing (desaturation) this halftime is divided by the SDR to get the desaturation halftime. Various MPTT's used 6 or 9 halftime tissues and SDR's were always 1.00 or less. These MPTT's are labeled HVAL01 through HVAL21, the "HVAL" signifying a HeO_2 MPTT Table and the 2 digit number reflecting the particular version. While a total of 21 sets of MPTT's were considered, not all were tested.

In the decompression tables in Appendices F (page F-1) and G (page G-4, G-28), a table of Blood Parameters appears on the same page as the MPTT Tables. These Blood Parameters are not part of the ascent criteria but show the values for various blood gas values assumed by the decompression model, the significance of which is discussed elsewhere (4). The values of the Blood Parameters used for development of HeO_2 algorithms were the same as used in developing the N_2O_2 algorithm and were not changed during this study.

Throughout this study only the number of halftime tissues, SDR's and individual MPTT values, as listed in Appendix E, were changed in attempting to compute safe decompression schedules. All other aspects of the decompression model remained unchanged throughout the study.

Compensating For Nitrogen:

In doing surface-supplied HeO_2 diving the divers start out saturated on nitrogen. Once they are breathing HeO_2 from the MK 15 or MK 16 closed circuit UBA the amount of nitrogen in the UBA cannot increase since none is added but it will decrease with time as gas is vented from the UBA during ascents. The decompression model tested here is a single inert gas model with 6-9 halftime tissues. The tissue halftimes cannot be considered as pure helium halftimes since some tissue nitrogen will be present. In addition, the MPTT Tables used to establish the ascent criteria reflect total inert gas tension, a small fraction of which will be nitrogen. Thus, the decompression tables tested are actually tri-mix tables with the majority of the inert gas being helium and a small fraction being nitrogen. This means that the EL-MK 15/16 DCM cannot be used for computing HeO_2 decompression schedules under conditions vastly different (e.g. switching between N_2O_2 and HeO_2) from the closed circuit environment tested here. Appendix B goes into more detail in describing the errors generated by the single inert gas model when two inert gases are breathed. In the square dive environment, these considerations are not significant. If this model is used for repetitive dive calculations the offgassing of helium at the surface while breathing air may have to be calculated using a two inert gas model. These are considerations which must be taken into account for future testing.

Test Profiles

Two types of test profiles were done, no-decompression and decompression. Appendix H provides comparison of profiles for each tested MPTT modification. When doing decompression profiles divers were compressed to the desired depth at a rate of 30 to 60 FSW/min but occasionally holds occurred so mean descent rate varied considerably from dive to dive. In order to keep profiles at a given depth comparable, the actual time for leaving the bottom was determined by total decompression time. A Hewlett Packard HP 1000 computer was programmed to compute total decompression time every 2 seconds along with the SAD. Thus, every 2 seconds the Diving Officer knew exactly how many minutes of decompression would be required if ascent were begun at that instant. Before the dive, a complete set of decompression tables were calculated using the EL-MK 15/16 DCA assuming a 60 FSW ascent and descent rate. Each one of these profiles had a total decompression time associated with it. Thus, if the planned schedule was 200 FSW for 30 min the divers were compressed to 200 FSW and after arrival stayed at 200 FSW until the total decompression time as calculated by the HP 1000 was the same as that in the 200 FSW for 30 min decompression table. At that instant decompression was begun and accomplished by matching diver depth with the SAD. By using this procedure the actual time at depth was adjusted to take total descent time into account such that upon leaving depth the theoretical tissue tensions for controlling tissues were the same as for the profile in the previously computed tables where a 60 FSW/min descent rate was assumed. Thus, when a 200 FSW/30 min profile is referred to in this report it means a profile where after arriving at 200 FSW divers stayed at depth until the total decompression time was the same as for a diver who left the surface and traveled to 200 FSW at exactly 60 FPM and stayed at depth for exactly 26.33 min (total bottom time equal to the 3.66 min descent

time plus 26.33 min at depth) and ascended at exactly 60 FPM during decompression. Thus, all profiles began ascent at very close to the same theoretical tissue tensions although actual times at depth may have differed by a few minutes depending on the actual descent time.

Decompression stops were in 10 FSW increments and the first stop could usually be reached at an ascent rate close to 60 FSW/min. When using the EL-MK 15/16 RTA there are no significant differences in offgassing rates at depths within 10 FSW of each other so small delays in leaving a stop or slow ascent rates between stops have no significant effect on total decompression time. At the 10 FSW stop, the chamber depth was 3 FSW with divers at the bottom of the 7 foot wetpot water column. Since it generally took 30 sec to travel this last 3 FSW, travel was begun when the HP 1000 computer showed 30 sec remaining at the 10 FSW stop. At the instant the HP 1000 showed that the divers could surface, all divers ascended to the surface, left the wetpot, and immediately began breathing chamber air. This procedure, when followed, always had the divers within 1 FSW of the surface when the HP 1000 showed that they could ascend to the surface. Once the chamber was at the surface, divers swam to the ladder and exited the chamber always breathing air.

No-Decompression Dives:

The EL-MK 15/16 RTA used to compute the SAD would also calculate the time remaining until the SAD would increase from 0 to 10 FSW. As long as the SAD was 0, the divers were within no-decompression limits. Thus, at any given depth no-decompression time was the time remaining before the SAD increased from 0 to 10 FSW and the remaining time until this happened was computed and displayed every 2 seconds. Programming constraints in the real time environment dictated that this time be computed assuming instantaneous ascent. Thus, once at depth, the no-decompression time was computed by calculating the shortest time it would take any tissue to saturate from its current value to its surfacing tension (10 FSW row of the appropriate MPTT Table). Since some tissue offgassing would always occur during ascent, this instantaneous no-decompression time would always have a shorter bottom time than a no-decompression time calculated taking a finite ascent rate into account.

During Phase I testing, decompression was begun when the SAD increased from 0 to 10 FSW and generally the SAD would decrease back to 0 FSW before the divers actually reached 10 FSW. Fig. 2 shows a depth profile for a 200 FSW dive with the SAD plotted as well. Decompression was started when the SAD increased from 0 to 10 FSW. If the 60 FSW/min ascent rate could have been maintained all the way to the surface, the divers would have arrived at the surface about 35 sec afer the SAD dropped back to 0. Because of slowed actual ascent shallow, the divers arrived at the surface almost 2 minutes after the SAD decreased to 0. Ideally, one would like to extend the time at depth so that during ascent the SAD decreases from 10 to 0 FSW the instant the divers reached 10 FSW. In Phase II the procedure for doing the 200 FSW no-decompression dive was modified to more closely approximate this ideal situation as shown in Fig. 3. Ascent from 200 FSW was not begun until the HP 1000 showed that a 1 minute stop at 10 FSW was necessary. During ascent the SAD actually increased to 20 FSW and upon arrival at 10 FSW a stop was taken

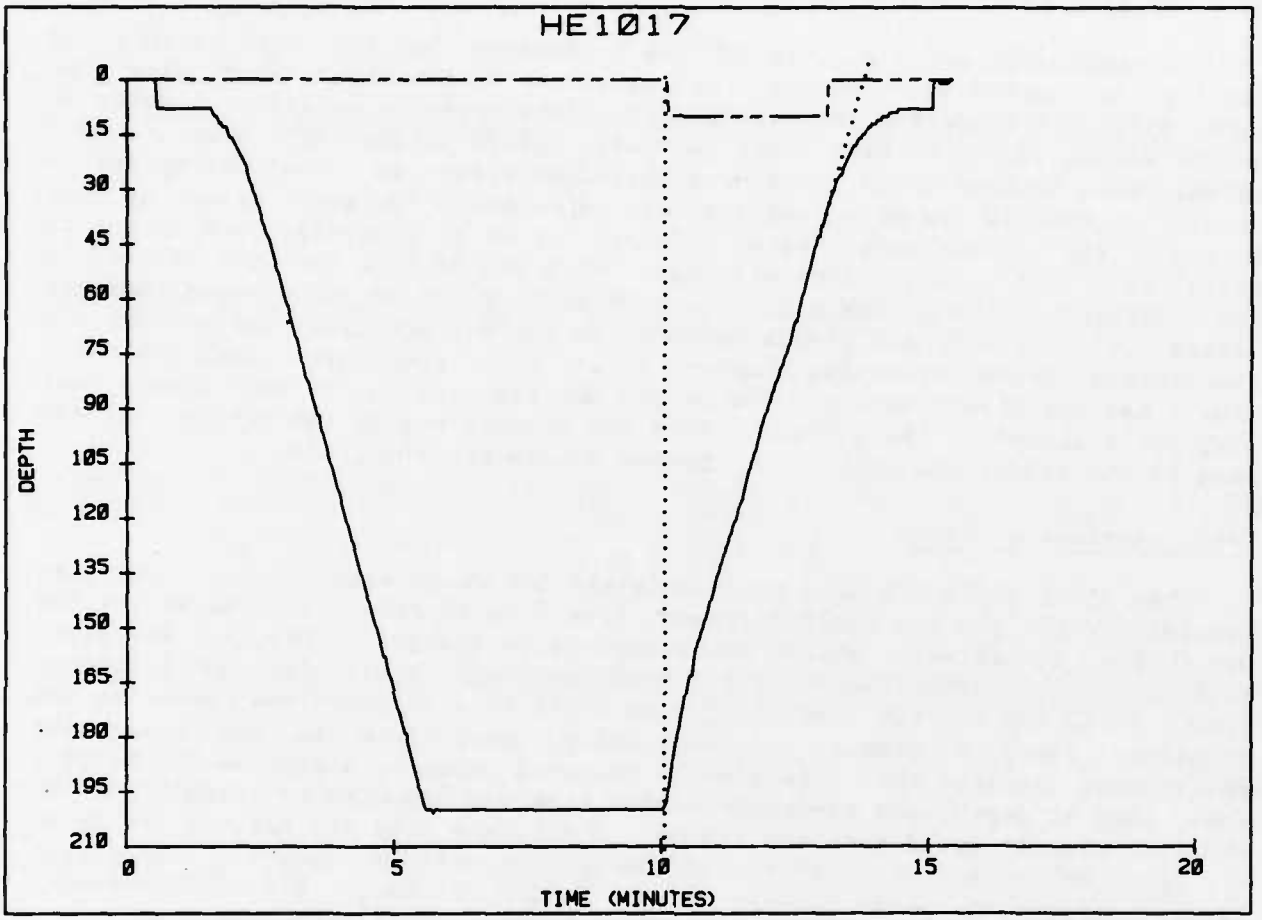

FIGURE 2. 200 FSW No-Decompression Profile. Same format as Figure 1. This is an HVAL03 schedule. After arrival at 200 FSW, ascent was begun at the time the SAD increased from 0 FSW to 10 FSW. A 60 FSW/min ascent rate was maintained until 30 FSW at which point it began to fall off. The divers were surfaced almost 2 min past the time the SAD returned to 0 FSW. Even if the ascent rate could have been maintained all the way to the surface (dotted line extrapolation), the divers would have surfaced about 35 seconds after the SAD decreased to 0 FSW.

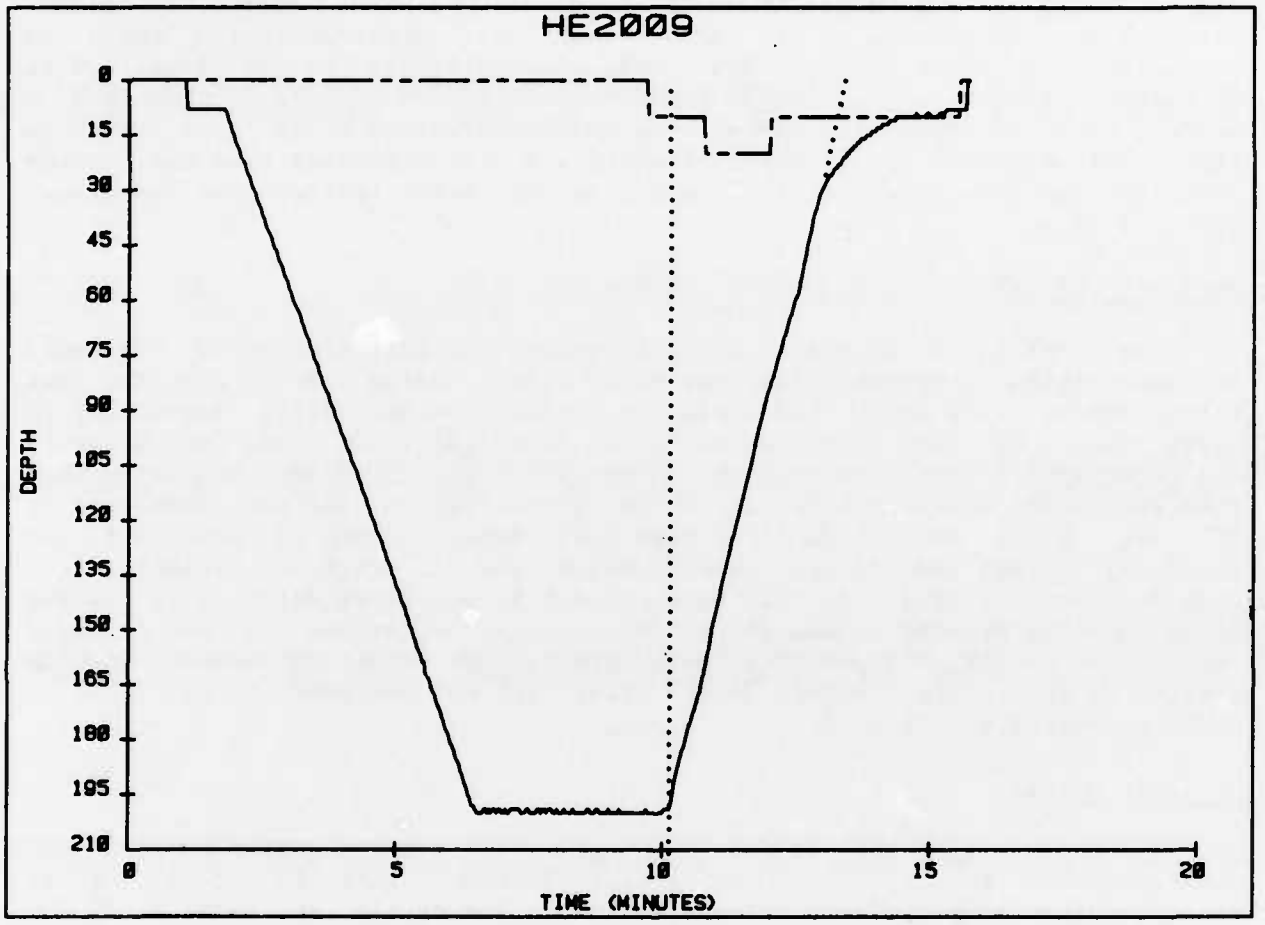

FIGURE 3. 200 FSW Minimal Decompression Profile. Same format as Fig. 1. In this HVAL06 schedule, ascent was begun with the HP 1000 computer showing about a 2 min stop at 10 FSW. Upon arrival at 10 FSW, there was a 1.2 min stop after which the divers were surfaced at the moment the SAD decreased to 0 FSW. This method allowed the decompression model to be followed exactly while getting as close to actual no-decompression times as possible.

until the SAD decreased to 0. This usually was less than 1 minute. The divers now arrived at the surface only 10 sec after the SAD decreased to 0. This dive was counted as a no-decompression dive but was actually a minimal decompression dive.

Since most of the no-decompression dives were done as illustrated in Fig. 2, these divers actually would have received some additional decompression during ascent. This means that the no-decompression limits as computed using these MPTT values would theoretically be too long. This potential problem was obviated because when MPTT values were adjusted to compute safe decompression dives, the no-decompression times were shortened (Table H-1, Appendix H). This shortening was always greater than the excess decompression time taken during the no-decompression testing done as illustrated in Fig. 2.

Deep Stop Dives:

The EL-MK 15/16 DCM predicted that taking the last stop at 20 FSW could be done without lengthening decompression time. Being able to take the last decompression stop at 20 FSW would be useful operationally, especially in heavy seas. In order to determine if the EL-MK 15/16 DCM would follow theory and actually allow the last stop to be taken at 20 FSW, 3 sets of dives were done where the divers remained at 20 FSW even after the SAD had decreased to 10 FSW. Since the EL-MK 15/16 RTA uses actual depth to compute tissue tensions, divers can always remain below the SAD without violating the decompression criteria. In this case, ascent from a diver depth of 20 FSW was begun when the HP 1000 showed about 30 sec remaining before the SAD deceased from 10 to 0 FSW. The divers were decompressed directly from 20 FSW and arrived at the surface within 30 sec after SAD had decreased to 0. This is shown graphically in Fig. 4.

HeO_2/Air Dives:

In these dives the divers switched from breathing the MK 15 HeO_2 breathing mix to air from open circuit SCUBA regulators at the first decompression stop shallower than 80 FSW. The switch was made at 80 FSW because at this depth the PO_2 on air is very close to 0.7 ATA. Thus, during all decompression shallower than 80 FSW, the diver would be breathing a PO_2 less than 0.7 ATA. Also, by not breathing air deeper than 80 FSW, any additional benefit from breathing a PO_2 above 0.7 ATA was eliminated. The divers decompressed according to the SAD as computed by the HP 1000 as if they were still breathing an HeO_2 mix from the MK 15. Thus, the decompression profile was not changed by breathing air. Instead, the intent was to see if the divers could safely decompress on an HeO_2 profile breathing air.

RESULTS

The dive series described in this report consisted of 5 phases. Phase I occurred from 21 January through 17 February 1982; Phase II from 29 March through 28 April 1982; Phase III from 5 August through 2 September 1982; Phase IV from 8 September through 21 September 1983; and Phase V from 9 April through 27 April 1984. Phases I-III were initially conceived as testing of square dive schedules to 300 FSW and Phase IV was initially designed to test

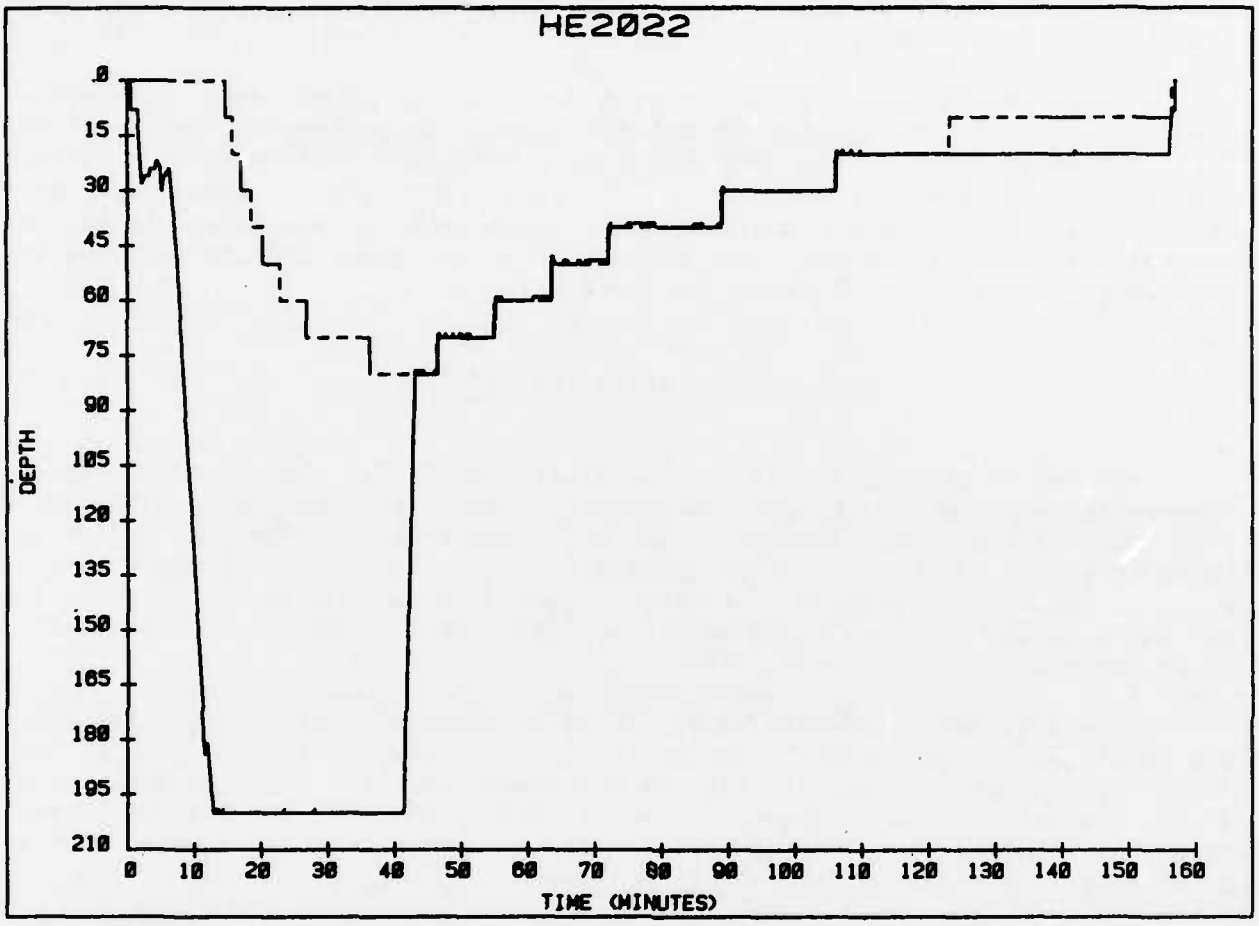

FIGURE 4. Deep Stop Profile. This HVAL07 Profile is almost the same profile as Fig. 1 but the total decompression time was 115 min due to a slightly longer bottom time. During decompression the actual depth was matched to the SAD until a depth of 20 FSW was reached where the divers remained at 20 FSW even after the SAD had decreased to 10 FSW. When the SAD finally decreased to 0 FSW, the divers were brought directly to the surface. Taking the last stop at 20 FSW did not lengthen the total decompression time over what it would have been if actual depth had been matched to the SAD all the way to the surface.

the emergency decompression procedure breathing air which were described earlier. An unexpectedly high incidence of decompression sickness (DCS) during Phase IV testing caused that protocol to be changed to investigate the reasons for this DCS. Phase V was then designed to test schedules as revised based on Phase IV testing and also to test the emergency air decompression procedure using the HeO_2/Air dives.

A total of 1582 man dives resulting in 59 cases of DCS were done using some 48 test profiles. Table 1 summarizes the depth/bottom time combinations for Profiles 1-44 using only HeO_2 and Table 2 Profiles 45-47 using air during decompression. (Note there is a profile 35 and 35a). Times for no-decompression dives are not designated for each HVAL and are given in square brackets. In the body of the table the number of man dives done is followed by the number of cases of DCS after the slash mark.

Phases I-III Testing (HVAL13 Tables)

Detailed results of Phases I-III are given in Tables 3 through 5. Table 3 shows the results of all no-decompression dives done during Phase I and the first part of Phase II. The particular no-decompression bottom time tested is shown in square brackets. All dives were done in cold water at temperatures given in the METHODS section except for 18 man dives at 60 FSW for 147 min, 19 man dives at 100 FSW for 34 min and 10 man dives at 120 FSW for 20 min; these dives being conducted in warm (71°F) water.

Table 4 gives the results of all Phase II decompression dives. Phase II was designed to produce an algorithm which could compute tables down to 200 FSW. It was during Phase II that the decompression dives with the last stop at 20 FSW were tested. These 28 man dives were all 200 FSW for 30 min and have their bottom times noted as 30D, and no cases of DCS occurred during these deep stop dives.

After completion of Phase II, Phase III was instituted to fill in gaps in decompression profiles from Phase II. Results of Phase III are given in Table 5. The goal after completing the first three phases was to have tested a no-decompression profile, one with the maximum permissible bottom time and one intermediate bottom time profile at 20 FSW increments from 60 to 200 FSW. Maximum bottom times were chosen to give a total dive time of 3-4 hrs. The final portion of Phase III was designed to extend the depth range to 300 FSW. During these deep dive tests, only two depths were used, 250 and 300 FSW and maximum bottom times were chosen to give a 3-4 hr total decompression time. No-decompression diving to these depths was judged to be impractical so a 10 min bottom time was chosen as the shortest bottom time to be tested.

Descriptions of all cases of decompression sickness for Phases I-III are given in Appendix C, Tables C-1 through C-3. The letter codes in the body of Tables 3 through 5 key the dives to the descriptions in Appendix C. Appendix D Tables D-1 through D-3, show the individual subject diving intensities for Phases I-III. (Note that subject numbers are the same for all five phases). On each specified date the profile number (from Table 1 and 2) of the profile

TABLE 1

RESULTS OF HeO_2 SCHEDULES TESTED

(Times in [] are For No-decompression Dives)

Profile #	Depth/Time (FSW) (Min)	Man Dives/DCS (Type)								
		No-D	HVAL07	HVAL09	HVAL11	HVAL12	HVAL13	HVAL16	HVAL21	Total
1	60 /[129]	9/0								9/0
2	[147]	54/1								54/1
3	170					29/1				29/1
4	80 / [50]	35/2								35/2
5	[67]	27/0								27/0
6	90					30/0				30/0
7	120					30/0				30/0
8	100 / [30]	33/1								33/1
9	[32]	30/2								30/2
10	[34]	38/1								38/1
11	[35]	27/1								27/1
12	[42]	27/5								27/5
13	60		20/0	10/0						30/0
14	90					30/2				30/2
15	95		20/1							20/1
16	100		10/1							10/1
17	120 / [19]	30/0								30/0
18	[20]	48/1								48/1
19	[22]	18/2								18/2
20	[25]	28/3								28/3
21	40			30/1	30/4	40/0	48/10	29/0		177/15
22	75		29/0							29/0
23	140 / [16]	18/0								18/0
24	[17]	7/1								7/1
25	65		30/2							30/2
26	150 / 30			30/1						30/1
27	50		10/0							10/0
28	60		20/0							20/0
29	160 / [11]	27/1								27/1
30	25					60/1	20/0			80/1
31	50					30/0				30/0
32	180 / 25					30/0				30/0
33	40					30/0				30/0
34	45		19/4	10/1						29/5
35	200 / [6]	30/0								30/0
35a	[7]	25/1								25/1
36	10		30/0							30/0
37	20			30/0						30/0
38	30		58/1@					20/2	30/0	108/3
39	250 / 10						29/0			29/0
40	25						29/1			29/1
41	260 / 22								10/1	10/1
42	300 / 10						30/1			30/1
43	15								20/0	20/0
44	20						32/0			32/0
TOTALS		511/22	246/9	110/3	30/4	309/4	188/12	49/2	60/1	1503/57

@ 28 man dives done with last stop at 20 FSW, Profile 30D in Table 4.

TABLE 2

RESULTS OF HeO_2/AIR SCHEDULES TESTED

Profile #	Depth/Time (FSW/MIN)	Man Dives/DCS (Type) HVAL21
45	80/90	29/1 (1)
46	100/60	30/1 (2)
47	300/18	20/0
TOTALS		79/2

Divers breathed 0.7 ATA constant PO_2 in He at depth and air beginning at the first stop shallower than 80 FSW for the entire decompression.

TABLE 3

PHASE I AND PHASE II NO-DECOMRPESSION TEST DIVE RESULTS

TOTAL MAN DIVES/DCS(TYPE)

(Times in [] are no-decompression bottom times and included 60 FSW/min descent time)

DATE (1982)	MOD	60 FSW	80 FSW	100 FSW	120 FSW	140 FSW	160 FSW	200 FSW
PHASE I 1/21	HVAL01	[129 min] 9/0		[35 min] 9/0			[11 min] 10/1(1)a	
1/22	HVAL02	[147 min] 10/0		[42 min] 9/0		[17 min]	[11 min] 8/0	[7 min]
1/23		8/0		9/2(1)b 1(2)				9/0
1/25		9/0		9/2(1)c		7/1(1)d		
1/27	HVAL03		[67 min]	[35 min] 18/1(1)e	[25 min]		[11 min] 9/0	[7 min]
1/29					9/0			16/0
2/1			9/0		19/2(1)f 1(2)			
2/5	HVAL04		[67 min] 9/0		[22 min] 18/1(1)g 1(2)			
2/8	HVAL05	[147 min]	[67 min] 9/0	[34 min]	[20 min] 18/0	[16 min]		
2/10				9/0#		18/0		
2/12		9/1(2)h		10/0	10/1(2)i			
2/15		10/0*			20/0*			
2/17		8/0*		19/1(1)*1				
PHASE II 3/29	HVAL06			[32 min]	[19 min] 30/0			[6 min]
3/30				30/1(1)k 1(2)				
3/31								30/1(1)@1

* Warm Water 71°F
\# Migrane in one diver
@ Post Dive Headaches in 2 Other Divers

443 Man Dives
19 cases DCS

Letters Key DCS to Descriptions in Appendix C

TABLE 4

PHASE II DECOMPRESSION TEST DIVE RESULTS

TOTAL MAN DIVES/DCS (TYPE)

(Times in [] are bottom times in min at indicated depth and include 60 FSW/min descent time)

Date (1982)	Mod	100 FSW	120 FSW	140 FSW	150 FSW	180 FSW	200 FSW
4/2	HVAL07						[10] 30/0
4/5							[30] 20/0
4/6							[30] 10/1(1)m
4/7					[50] 10/0 [60] 10/0		
4/8					[60] 20/0		
4/9		[95] 20/1(1)n					
4/12		[100] 10/1(1)o					[30D] 10/0
4/13							[30D] 9/0
4/14			[75] 9/0				[30D] 9/0
4/15			[75] 10/0				
4/16				[65] 10/0			
4/19				[65] 20/1(1)p 1(2)			
4/20			[75] 10/0				
4/21						[45] 19/4(1)q	
4/22		[60] 20/0					
4/23	HVAL09	[60] 10/0				[45] 10/1(1)r	
4/26							[20] 30/0
4/27					[30] 30/1(1)s		
4/28			[40] 30/1(2)t				

(D) Last stop on profile 20 FSW.

356 Man Dives
12 Cases DCS

Letters Key DCS to Description in Appendix C.

TABLE 5

PHASE III DECOMPRESSION TEST DIVE RESULTS

TOTAL MAN DIVES/DCS (TYPE)

(Times in [] are times in min at indicated depth and include 60 FSW/min descent time)

Date (1982)	MOD	60 FSW	80 FSW	100 FSW	120 FSW	160 FSW	180 FSW	250 FSW	300 FSW
8/5	HVAL11				[40] 30/3(1)u 1(2)				
8/6	HVAL12				[40] 30/0				
8/7					[40] 10/0		[25] 20/0		
8/9							[40] 20/0		
8/10							[40] 10/0		
8/11			[120] 30/0	[90] 10/0			[25] 10/0		
8/13			[90] 30/0						
8/16				[90] 20/2(1)v					
8/17		[170] 20/0							
8/18		[170] 9/1(2)w				[50] 10/0			
8/19						[50] 20/0			
8/20						[25] 30/0			
8/23						[25] 30/1(1)x			
8/24	HVAL13							[25] 10/0 [10] 20/0	
8/25								[25] 19/1(2)y	
8/30						[25] 20/0			
8/31									[20] 10/0 [10] 20/0
9/1									[20] 10/0 [10] 10/1(1)z
9/2								[10] 9/0	[20] 12/0*

* 2 Divers did not exercise on bottom

479 Man Dives
10 Cases DCS

Letters Key DCS to Descriptions in Appendix C.

dove by each subject is given. All cases of DCS are noted as well as dives which were not completed by the subject (usually because of ear squeezes or equipment malfunction). Note in Table D-1 that profile 17N was a 120 FSW for 19 min dive done using a nitrogen diluent. These dives are only reported in this table for completeness and are not included anywhere else, but were previously reported with the N_2O_2 algorithm test results (4).

Based on the results of Phases I-III a comprehensive set of decompression tables using HVAL13 were generated by the program TBLP7 (5) and are given in Appendix F. Table 6 summarizes the dives from Table 1 which had shorter decompression times and/or stop depth/time distributions significantly different from the HVAL13 schedules established during Phases I-III and therefore fell outside of the HVAL13 limits. Table 6a shows the dives which did fall within these limits. Based on these results, the expected incidence of DCS was 4.0% for no-decompression dives, 3.4% for decompression dives and 3.9% overall (Table 6a), assuming a binomial distribution at the 95% confidence level. It was thought initially that these would be the final set of HeO_2 Decompression Tables.

Phase IV Testing

Phase IV was instituted to test an emergency procedure being developed for use with the 0.7 ATA constant PO_2 in He profiles in the operational environment. This procedure was designed to address the problem of a closed circuit UBA failure at depth where the diver was no longer within no-decompression limits. The procedure called for lowering to the diver an open circuit SCUBA regulator on a long hose supplied with air from SCUBA bottles in a surface support craft. The diver would then breathe air all the way to the surface following the appropriate 0.7 ATA constant PO_2 in He decompression schedule to the surface. Theoretically this should cause no problem from a decompression standpoint since when breathing air inspired helium tension would be zero and helium offgassing should increase. Since the diver would start decompressing right away in the event of a UBA failure he would not incur any significant nitrogen uptake from breathing the air, which might increase his decompression obligation. In testing this procedure air was not breathed until the diver was shallower than 80 FSW which meant the PO_2 breathing air was always less than 0.7 ATA. This precluded against any possible benefit from breathing an increased oxygen tension at depth.

In training for Phase IV as initially planned, a series of 120 FSW for 40 min HeO_2 dives were planned, to be done in exactly the same manner as Phase II and III dives. During Phase III, 40 DCS-free man dives had been done on this schedule using HVAL12 which generates the same decompression schedule as HVAL13 (Appendix H). Two groups of divers, A and B, were to participate in the study. Group A dove first and the 7 cases of DCS which resulted after only 17 man dives (Table 7) caused cancelling of Group B dives and reconsideration of the proposed protocol.

Given the previous lack of DCS on the 120 FSW for 40 min schedule, the only explanation that seemed plausible to account for the unexpectedly high DCS incidence in the Phase IV Group A divers was that the diving intensity from Phases I-III conferred an increased tolerance to DCS on the divers in those phases thus resulting in the low DCS incidence when they dove the 120/40 schedule. This phenomenon has been previously described in both tunnel workers

TABLE 6

DIVES FROM TABLE 1 NOT WITHIN HVAL13
LIMITS ESTABLISHED DURING PHASE I-III TESTING

(Depth/Time In FSW/Min)

NO-DECOMPRESSION DIVES

Profile	Depth/Time	Man-Dives/DCS	Reason
1	60/129	9/0	Bottome time too short
4	80/50	35/2	Phase IV Dives
8	100/30	33/1	Phase IV Dives
12	100/42	27/5	Bottom time too long
19	120/22	18/2	Bottom time too long
20	120/25	28/3	Bottom time too long
24	140/17	7/1	Bottom time too long
	TOTAL	157/14	

DECOMPRESSION DIVES

Profile	Depth/Time	HVAL	Man-Dives/DCS	Reason
21	120/40	09	30/1	Short Decompression
		11	30/4	Short Decompression
		13	48/10	Phase IV & V Dives
		16	29/0	Phase IV & V Dives
38	200/30	16	20/2	Phase IV & V Dives
		21	30/0	Phase IV & V Dives
43	300/15	21	20/0	Phase IV & V Dives
		TOTAL	207/17	

TABLE 6a

DIVES FROM TABLE 1 FALLING WITHIN HVAL13
LIMITS ESTABLISHED DURING PHASE I-III TESTING

Total no-decompression dives from Table 1 (man dives/DCS)	511/22
Less dives from Table 6 not within HVAL13 limits	157/14
TOTAL no-decompression dives falling within HVAL13 limits	354/8
Total decompression dives from Table 1 (man dives/DCS)	992/35
Less dives from Table 6 not within HVAL13 limits	207/17
TOTAL decompression dives falling within HVAL13 limits	785/18

Dives Falling Within HVAL13 Limits

	Man Dives	DCS	Expected Incidence @ (95% Confidence)
No-Decompression	354	8	4.0%
Decompression	785	18	3.4%
TOTAL	1139	36	3.9%

@ Expected Incidence Computed Assuming Binomial Distribution.

and divers and a good review of applicable literature is given by both Hempleman (21) and Vann (19). Working on the premise that some sort of "work-up" phenomenon existed it was decided to forego testing of the emergency air breathing procedure during Phase IV and investigate this postulated phenomenon. Two work-up scheules were devised. The 80 FSW no-decompression work-up dive had a 50 min bottom time which was 17 min less than the 67 min no-decompression limit tested in Phase I. This was considered a particularly non-stressful dive. The next work-up dive was 100 FSW no-decompression dive for 30 min (3 min less than the HVAL13 no-decompression limit) which was considered moderately stressful. Based on analysis of dives from Phases I-III (as will be discussed) a minimum elapsed time of 48 hrs between work-up dives was established.

The results of Phase IV are given in Table 7. Testing of the effects of the work up schedules was begun with Group B divers because Group A's previous 120/40 dive may have resulted in working these divers up thus increasing their toelrance to DCS. Group B, who had done no diving within the previous 2 weeks, was able to dive every day for 3 consecutive days, diving the two work-up dives and then the 120 FSW/40 min schedule. The incidence of DCS on the 120/40 schedule was much lower than that which occurred during Group A's initial dive (1 DCS in 16 man dives vs 7 cases in 17 man dives) which indicated a rather powerful work-up phenomenon. It was surprising that there was 1 case of DCS during the 80 FSW/50 min dive, a dive considered to have almost no decompression stress. The following week Group A dove the work-up dives (where surprisingly 1 case of DCS occurred on each of the workup dives) followed by the 120/40 schedule. The 11 day layoff since the initial 120/40 Group A dive was considered sufficient to allow any increased DCS tolerance from that dive to have worn off. The incidence of DCS was lower than the initial dive but higher than the Group B incidence (Table 7). If one assumes that DCS follows a random (binomial) distribution then the expected incidence of DCS on the 120/40 schedule for Group A at the 95% confidence level fell from >60% (7 DCS in 17 man dives) to approximately 25% (1 case in 16 man dives).

The descriptions of the DCS which occurred during Phase IV are given in Table C-4 of Appendix C. The individual diving intensity is given in Table D-4 of Appendix D. Of the 7 Group A divers who got DCS on the initial 120/40 dive, two (#122, 123) did no further dives, one (#118) dropped out after completing only the 80 FSW work-up dive without incident, one (#111) did not dive the second 120/40 schedule because of DCS during a work-up dive and three (#128, 129, 137) went on to complete all work-up dives and the second 120/40 schedule. Of these three only one diver (#128) experienced DCS and that was on the second 120/40 schedule. Of the 12 other Group A subjects who did not get DCS on the first 120/40 dive (#133 and 113 did not complete it because of equipment failure), two (#36 and 117) dropped out, one (#71) got DCS on the 80 FSW work-up dive and 8 (#4, 70, 113, 115, 121, 125, 133, 135) successfully completed the two workup dives and the second 120/40 dive. One diver (#134) switched to Group B and successfully completed the second 120/40. A total of 4 new subjects entered Group A for the second set of dives. One subject (#120) had suffered DCS during the first Group B 80 FSW work-up dive and switched to Group A where she successfully completed all subsequent profiles. Three other subjects (#47 124, 131) entered Group A on Sept. 19th having never dove the initial Group A 120/40 profile but dove only the second set of Group A profiles.

TABLE 7

PHASE IV DECOMPRESSION

TEST DIVE RESULTS

(All dives are HVAL13)

	Schedule FSW/min	120/40	80/50*	100/30*	120/40
Group A	Date (1983)	9/8	9/19	9/22	9/23
	Result [Man Dives/DCS (Type)]	17/4(1)aa 3(2)	18/1(2)bb	16/1(2)cc	15/2(2)dd
Group B	Date	-	9/13	9/14	9/15
	Result (Man Dives/DCS (Type))	-	17/1(1)ee	17/0	16/1(1)ff
Totals		17/7	35/2	33/1	31/3

* Sub No-Decompression Dives
HVAL13 No-Decompression Limits 80/67, 100/33

Letters Key DCS to Description in Appendix C.

Of the Group B dives, only 3 did not complete all three dives. Diver #120 got DCS on the 80 FSW work-up dive and went on to successfully complete three dives later on with Group A. Diver #53 dropped out after having successfully completed both work-up dives and diver #134 did the initial 120/40 dive with Group A then switched to Group B, completing only the 100 FSW work-up and then the 120/40 dive.

Phase V Testing (HVAL21 Tables)

The results of the Phase IV dives indicated that HVAL13 Tables would probably be unsafe for divers who have had no recent diving experience but would probably be safer after the divers had become worked up after having doing several HeO_2 dives. However, the work-up dives done in Phase IV would not be sufficient to confer adequate resistance to DCS. With this in mind, Phase V was designed to test a revised computer algorithm on "un-worked-up" divers. The results of Phase V are given in Table 8. In order to minimize any work-up phenomenon divers had a minimum of 36 hours off between dives as demonstrated in Table D-5 of Appendix D. The initial lengthening of the 120 FSW for 40 min schedule using HVAL16 proved successful but a further modification resulting in HVAL21 was necessary afer 2 cases of DCS occurred on the 200 FSW for 30 min schedule. The final 60 man-dives in the 200-300 FSW range using HVAL21 resulted in only a single case of DCS. At this point the emergency air breathing procedure was tested on some 70 man dives resulting in only 2 cases of DCS.

The final result of Phase V was the HVAL21 set of MPTT's which were used to compute the set of Decompression Tables in Appendix G. Of all the dives done breathing only HeO_2 in Table 8, only 20 man dives on the HVAL16 200/30 profile, which resulted in 2 cases of DCS, fall outside of the final HVAL21 limits based on total decompression time. The 89 man dives which did fall within the final limits resulted in 1 case of DCS giving an expected incidence of 5.5% assuming a binomial distribution at a 95% confidence level. The 79 man dives done using air during decompression resulted in 2 cases of DCS giving an expected incidence of 8.0%.

UBA Oxygen, Carbon Dioxide, and Nitrogen Levels

A total of 8147 oxygen samples were obtained during Phases I-III. The values were normally distributed with a mean $\pm$ s.d. of 0.755 ± 0.069 ATA. It should be remembered that the MK 15 set point of 0.7 ATA reflects the PO_2 level at which PO_2 is added to the breathing loop, not the mean PO_2 level which will be somewhat higher. When the PO_2 samples were tabulated separately for divers who suffered DCS and those who did not, the following were obtained (mean $\pm$ s.d.):

Divers with DCS	0.741 ± 0.081 ATA	n = 254
Divers without DCS	0.755 ± 0.069 ATA	n = 7893
All Divers	0.755 ± 0.069 ATA	n = 8147

The 0.014 ATA difference in mean PO_2 between the two groups is physiologically insignificant. Examination of individual PO_2 values showed that only one diver may have suffered DCS as a result of a low PO_2 level. Diver #20 was noted to have PO_2 levels from 0.31 -0.51 ATA during the 40 and 10 FSW stop during a 140/65 dive on April 19 (Appendix C, Table C-2; Table 4).

TABLE 8

PHASE V DECOMPRESSION TEST DIVE RESULTS

TOTAL MAN DIVES/DCS (TYPE)

(Times in [] are bottom times in min at indicated depth and include 60 FSW/min descent time)

Date (1984)	Mod	80 FSW	100 FSW	120 FSW	200 FSW	260 FSW	300 FSW
4/9	HVAL16			[40] 19/0			
4/10				[40] 10/0			
4/12					[30] 20/1(1)gg 1(2)		
4/13	HVAL21				[30] 10/0		
4/16					[30] 10/0		
4/17					[30] 10/0	[22] 10/1(2)hh	
4/19							[16] 20/0
4/20	HVAL21 Air						[18] 10/0
4/23	Stops		[60] 20/1(2)ii				
4/24							[18] 10/0
4/26		[90] 20/1(1)jj					
4/27		[90] 9/0	[60] 10/0				

Letters key DCS to descriptions in Appendix C.

HeO_2 Dives	109 Man Dives	3 DCS
HeO_2/Air Dives	79 Man Dives	2 DCS

This diver eventually suffered Type 2 DCS from that dive. A low PO_2 could not be implicated as a caustive factor in other cases of DCS. Low PO_2 levels were not only confined to Diver #20, two other divers who never suffered DCS were noted to have PO_2 levels between 0.31-0.51 ATA for 30-100 min during Profiles #14 and #38. Thus, a low PO2 level in and of itself does not overcome the effects of individual variation.

Analysis of UBA CO_2 partial pressure levels was more straightforward. Values ranged from 0.0 mmHg to 7.6 mmHg. However, only 0.2% of the 6825 samples were above 3.8 mmHg and in these cases divers changed to a UBA with a fresh CO_2 canister. None of the divers who suffered DCS had a PCO_2 above 3.8 mmHg on any sample.

Nitrogen partial pressures were difficult to analyze because of the wide inter-subject variability and because the partial pressure was constantly decreasing throughout the dive. Nitrogen partial pressure samples taken during the first 10 min of time at each of the depths used during Phase I-III testing ranged from mean values of 0.31 to 0.17 ATA with standard deviations as high as 50% in some instances. Nitrogen partial pressure variation was due to many uncontrolled variables such as diver lung volume when he began breathing on the MK 15 and the amount of UBA offgassing from leaks and face mask clearing. The mean nitrogen partial pressure taken during the first 10 min at depth was depth independent and the mean of the 11 means at each depth was 0.24 ± 0.04 ATA. Nitrogen partial pressures for the divers who suffered DCS did not appear unique in any way and no particular relationship between high nitrogen partial pressure and DCS was evident. Nitrogen partial pressures taken during decompression were generally less than 0.10 ATA and dropped with each stop as would be expected from UBA offgassing. The variability in these samples precluded analysis at this time.

In summary, UBA O_2, CO_2 and N_2 levels appeared to play little or no role in the subsequent development of DCS except for one diver who suffered DCS after having a low PO_2 during decompression. The decompression model developed as a result of this dive series was adjusted to provide safe dives given the wide variation in nitrogen partial pressures. Operationally, divers are instructed to exhale completely (rather than inhaling as done in this study) before going on their UBA which should reduce nitrogen partial pressures below the levels encountered in this study. As is evident from the longer decompression times required when using a nitrogen diluent (4), reduction of nitrogen partial pressure when using a helium diluent will be beneficial.

DISCUSSION

The goal of this study was to produce a computer algorithm which could compute acceptably safe 0.7 ATA constant PO_2 in He decompression tables to depths of 300 FSW. Since these tables would be used mainly by EOD divers and since the EOD diver will be doing mainly single square dives, no repetitive diving was done at this time. No-decompression dives were tested first to establish the surfacing MPTT values, the ones which are in the first row of the MPTT Tables (Appendix E). Only when these had been firmly established did the study move on to test decompression dives. The MPTT Tables HVAL01-09 show 9 halftime tissues. These 9 tissues were a carryover from the MK 15/16 DCM as it was used to develop an N_2O_2 algorithm (4) but as testing progressed it was

found that halftimes beyond 120 min were unecessary for computation of safe decompression schedules, and only 6 tissues were used for HVAL11 - HVAL21.

Up through HVAL09 the saturation/desaturation ratio (SDR) for all tissues was 1.00. At this point the SDR should be considered a strictly empirical variable which can be used to slow tissue offgassing and thereby lengthen decompression without affecting the surfacing MPTT's. In the EL-MK 15/16 DCM the tissue halftime shown in the MPTT Tables is the halftime for gas uptake. During desaturation the tissue time constant (K) is multiplied by the SDR, so if the SDR is less than 1.0 the tissue halftime ($T_{1/2} = \ln(2)/K$) increases. In developing the HVAL13 MPTT's from HVAL09, only the 120 halftime surfacing MPTT was changed in HVAL11, all other adjustments were made to the SDR (Appendix E). The HVAL13 SDR's were retained in HVAL16 and HVAL21 and adjustments made only in the MPTT's. Note that the Blood Parameters (Appendix F, F-1; Appendix G, G-4, G-28), which are assumed constant and independent of depth, were the same values used in developing the N_2O_2 decompression tables (5) for all decompression computations in this study. The adjustment for the MPTT's with increasing depth was the same for all tissues and was made by adding a constant 12 FSW for each 10 FSW increase in depth for all HVAL's through HVAL16. This was done to make the model fit the HeO_2 saturation excursion limits (11). In developing HVAL21 this depth adjusment was reduced to 11 FSW for each 10 FSW of depth increase. The implications of this adjustment on the final model will be discussed later.

Development of No-Decompression Limits

A summary of all dives done in developing the no-decompression limits was given in Table 3. This effort encompassed all the dives of Phase I and the first 90 man dives of Phase II using HVAL06. In general, the no-decompression limits are controlled by the first row of MPTT's in each MPTT Table, the so-called surfacing values. Development of no-decompression limits, therefore, concerned itself only with these values, all other MPTT's being irrelevant for no-decompression dives.

HVAL01 was designed to approximate the previously estabished least conservative HeO_2 no-decompression limits using a 25% fixed FO_2 in helium established during development of the MK 6 mixed gas SCUBA tables, (Fig. 2, ref. 12). Since these limits had already been tested, this was assumed to be a reasonable starting point. Using a 25% fixed FO_2, the EL-MK 15/16 DCA using HVAL01 predicts no-decompression limits of 129 min at 60 FSW, 47 min at 100 FSW, and 20 min at 160 FSW. The no-decompression limits from Fig. 2 of reference 12 are 134 min at 60 FSW, 48 min at 100 FSW, and 19 min at 160 FSW. When a constant 0.7 ATA PO_2 was substituted for the constant 25% FO_2 in the EL-MK 15/16 DCA the no-decompression limits were 129 min at 60 FSW, 35 min at 100 FSW, and 11 min at 160 FSW.

During Phase I and Phase II testing, the single case of DCS which occurred afer the 160 FSW dive no-decompression indicated that this limit could probably not be extended beyond 11 min but the absence of DCS following the 60 FSW and 100 FSW no-decompression dives indicated that the predicted limits could be extended (Table 3). The 60 FSW no-decompression limit was successfully extended to 147 min but the 100 FSW limit could not be extended to 42 min, and in Phase I it was evetually backed off to 34 min. The 60 FSW no-decompression limit stayed at 147 min and the 80, 140, 160 and 200 FSW

limits were not changed significantly during Phase I. The initial testing of the 25 min no-decompression limit at 120 FSW using HVAL03 produced a rather severe case of Type 2 DCS in one subject (Annex C, Table C-1, Diver #35) which eventually led to progressive shortening of this no-decompression limit to 20 min.

At the end of Phase I testing, selected dives at 60, 100, and 120 FSW were done in warm (71°F) water to address the hypothesis that cold water would decrease gas uptake (due to decreased peripheral blood flow) and thus allow longer no-decompression limits than could be obtained in warm water. The incidence of 1 case of DCS in 57 man dives, due to the one minor case of DCS which occurred after a 100 FSW no-decompression warm water dive, was not judged significantly different from the cold water experience so the above hypothesis was not accepted and all further diving was done in cold water.

At the completion of Phase I, it was felt that safe no-decompression limits had been established at 60, 80, 140 and 160 FSW. In reviewing Phase I results, further testing at 100 and 120 FSW was deemed necessary to verify the safety of these no-decompression limits. It was also decided that retesting the 200 FSW no-decompression limits was necessary because (as discussed previously) the procedure used to do these dives (leaving the bottom when the SAD increased from 0 to 10 FSW) caused the divers to surface 1-2 min after the model predicted surfacing was possible (Fig. 2). While this occurred for all no-decompression dives, the difference for the 200 FSW dives was especially significant considering the short no-decompression time. The procedure was changed during Phase II as previously discussed to more closely follow the decompression model (Fig. 3). Additionally, the frequency and severity of the Type 2 DCS which occurred during Phase I testing caused a more conservative approach to be used in computing decompression schedules for subsequent phases. Five of the 16 cases of DCS from Phase I were Type 2 and of these five, three had frank weakness and one of these three also had bladder dysfunction requiring an extended treatment. In testing of the N_2O_2 version of the MK 15/16 RTA there were 6 cases of Type 2 DCS, all occuring during Phase I N_2O_2 testing (3) with no Type 2 cases during Phase II N_2O_2 testing (4). Also, of the Type 2 cases which did occur during N_2O_2 testing, only one was of a severity comparable to the cases experienced in this study.

Phase II testing started out with no-decompression tables based on HVAL06 which was designed to specifically reduce the 100 FSW and deeper no-decompression limits, but which as a side effect also reduced the 80 FSW limit by 6 min (Annex H). Surprisingly, DCS occurred after the 100 FSW no-decompression dive even with a reduction of 2 min in the no-decompression limit but the one Type 2 case was pain with accompanying paresthesia and no signs of weakness or other CNS involvement. The thirty DCS-free dives on the 120/19 no-decompression schedule and the single Type 1 DCS on the thirty 200/6 no-decompression dives were considered an acceptable indication of the safety of these dives.

Development of HVAL13 Decompression Tables (Phases I-III)

Theoretical Considerations:

During Phase I testing and the initial no-decompression portion of Phase II testing, attention had been focused only on the surfacing MPTT values and

in HVAL01 through HVAL06 these MPTT values increased by 10 FSW for each 10 FSW increased in depth as they had been in developing the N_2O_2 algorithm (4). HVAL07 was the initial MPTT Table modification for decompression dives and led to HVAL09, 11, 12 and eventually HVAL13.

In developing HVAL07, the surfacing MPTT values for HVAL06 were retained but the depth increment increase was changed. In determining what the depth increment increase in MPTTs should be, certain aspects of saturation HeO_2 diving were considered. The first consideration was the saturation decompression rate, which for the EL-MK 15/16 DCM is constant as long as the PO_2 is constant. Current U.S. Navy saturation diving practice uses a decompression rate of 6 FSW/hr until a depth of 200 FSW is reached, 5 FSW/hr to 100 FSW, 4 FSW/hr to 50 FSW and 3 FSW/hr to the surface. Decompression is only done 16 hours out of each 24 so all these rates should be multiplied by 2/3 to get a mean rate. Decompression from 1000 FSW using current U.S. Navy saturation decompression rates takes 273.75 hours if one begins decompression from 1000 FSW without doing an upward excursion. This is a mean rate of 3.65 FSW/hr. The equation for the rate of tissue offgassing for the EL-MK 15/16 DCM is:

$$dP/dT = K \cdot (2.8 - PO_2)$$

Using a PO_2 value of 0.40 ATA (13.2 FSW, where 33 FSW = 1 ATA) and a value of -3.65 FSW/hr for dP/dT and solving the above equation for K gives a value of 0.351 hrs^{-1} which corresponds to a theoretical tissue halftime of 118 min. This means that to explain the HeO_2 decompression rates with the EL-MK 15/16 DCM, tissue halftimes above 120 min are not needed. This offgassing rate of 3.65 FSW/hr will only apply if every 1 FSW of offgassing allows an ascent of 1 FSW. This means MPTT's must increase 10 FSW for each 10 FSW increase in depth. If more than 1 FSW of offgassing is required, the ascent rate will be slowed proportionally.

The other aspect of saturation decompression which was considered in developing HVAL07 was the unlimited duration upward excursion limits. These limits should provide an estimate as to what the maximum permissible tissue tension is at the post excursion depth since all tissues will have been saturated at the initial storage depth. The results of this analysis are given in Table 9. Note that all partial pressure units have been converted to units of FSW where 33 FSW = 1 ATA = 760 mmHg. The Inert Gas Load column shows the computed inert gas tension after saturation at the initial depth. In keeping with the assumptions of the EL-MK 15/16 DCM inert gas tension was assumed equal to ambient pressure less alveolar O_2 and CO_2 tensions. A surfacing MPTT value of 50 FSW for the 120 min tissue means that at a PO_2 of 0.4 ATA (13.2 FSW), direct ascent from a saturation depth of 32 FSW would be possible (50 + 13.2 + 1.5 - 33 = 31.7) assuming a CO_2 partial pressure of 1.5 FSW. Using a surfacing tension of 50 FSW and a depth increment increase of 12 FSW increase in MPTT for each 10 FSW increase in depth gives a maximum permissible tissue tension of 230 FSW for a depth of 150 FSW and 410 FSW at a depth of 300 FSW (remember in the MPTT table the value in each row is the maximum value allowed before ascent to the next shallower depth can be done, thus the MPTT values in the 160 FSW column are the tensions which must be reached before ascent to 150 FSW can be done, or conversely they are the maximum tensions allowed at 150 FSW without violating the ascent criteria).

TABLE 9

COMPUTED INERT GAS LOADS AT POST EXCURSION DEPTHS

Initial Depth (FSW)	Final Depth (FSW)	Inert Gas Load (FSW)
220	150	238
400	300	418
740	600	758
1000	835	1018

$$\text{Inert Gas Load} = P_{AMB} - P_{A_{O_2}} - P_{A_{CO_2}}$$

$$P_{AMB} = \text{Initial Depth} + 33 \text{ FSW}$$

$$P_{A_{CO_2}} = 1.5 \text{ FSW}$$

$$P_{A_{O_2}} = .4 \text{ ATA} = 13.2 \text{ FSW}$$

Note: All partial pressures are given in FSW where 33 FSW = 1 ATA = 760 mmHg.

To further assist in establishing maximum permissible gas tensions at depth, some additional data gathered during development of the unlimited saturation limits was considered (13). In that series an upward excursion to 300 FSW was possible after saturation at 400 FSW. However, after saturation at 300 FSW, a 3 hr downward excursion to 450 FSW produced mild DCS upon return to 300 FSW. This indicated that the maximum 450 FSW excursion limit from a 300 FSW storage depth was about 3 hours. Refering to Table 9, the maximum inert gas tension at 300 FSW was 418 FSW. At a depth of 450 FSW the inert gas tension at a PO_2 of 0.4 ATA would be (450 + 33 -14.7 =) 468.3 FSW. In the EL-MK 15/16 DCM, gas uptake is given by the equation:

$$P = P_A - (P_A - P_I) \cdot e^{-K \cdot T}$$

where:

P_A is ambient inert gas tension.
P_I is initial inert gas tension.
K is the tissue time constant.
T is time in min.

Using a value of 468.3 for P_A, 318.3 for P_I (saturation value at 300 FSW) and 418 FSW for the final gas tension (P) and 180 min for T and solving for K one obtains a value of $6.070 \cdot 10^{-3}$ min^{-1} which represents a tissue halftime of 114 min. So a maximum permissible tissue tension for the 120 min of 418 FSW would predict a maximum 450 FSW downward excursion time of about 3 hours from a saturation depth of 300 FSW.

The above analysis is based on the assumptions used in developing the EL-MK 15/16 DCM (4) and is presented to give a thorough picture of the considerations used in constructing HVAL07. The object was to develop a decompression model which could explain as much as possible of the current helium-oxygen decompression data in the literature. While a lot of rationalization went into constructing HVAL07, some of the initial data fitting had to be compromised in developing subsequent MPTT's as the reality of actual test results accumulated.

Decompression Schedule Testing:

The HVAL07 MPTT proved remarkably long lived and survived most of Phase II testing (Table 4). When the 180 FSW for 45 min schedule was tested the 4 cases of DCS which occurred caused the 120 min surfacing tension to be reduced from 50 FSW to 48 FSW. Longer tissue surfacing tensions were reduced but these longer tissues never controlled any stops during that dive. The resulting MPTT table was HVAL09. The main effect of HVAL09 was to lengthen the 180 FSW for 45 min schedule from 146 min total decompression time to 164 min (Appendix H). The 100/60, 120/40, 150/30, 200/10 and 200/30 schedules were unchanged but other schedules were lengthened slightly. Testing of HVAL09 appeared successful until the last dive of Phase II which was a 120 FSW for 40 min dive (Table 4). Diver #40 initially noted some shoulder discomfort 2 min before surfacing which increased after surfacing. Hip pain and upper extremity weakness developed and the diver was recompressed within 10 min of surfacing where complete relief was noted on arrival at 60 FSW. A complete

neurological examination performed at 60 FSW by a Diving Medical Officer was normal. A Treatment Table 6 was completed and the diver appeared normal upon surfacing. Within 10 min after surfacing, severe CNS DCS occurred leading to a 36 hour stay at 60 FSW with a 30 hr decompression. After several follow-up treatments, the diver eventually became completely asymptomatic 8 months later (Annex C, Table C-2). It should be noted that this diver showed a remarkable sensitivity to DCS from Phase I (Appendix D, Table D-1).

In planning Phase III, the fact that only one diver suffered symptoms of DCS on the 120/40 schedule and that he appeared unusually susceptible to DCS led to lengthening of that schedule by only 3 min with HVAL11. Since the no-decompression limits had appeared safe, the 120 min surfacing tension was restored to 50 FSW but its SDR was reduced from 1.00 to 0.83. This had the effect of making this tissue act like a 145 min tissue during offgassing but giving HVAL11 the same no-decompression limits as HVAL06 with the exception of the 80 FSW limit which was increased approximately 6 min to 67 min. Since the 120/40 schedule was the last one dove on Phase II and had produced DCS, it was decided to retest that schedule before moving on to deeper, longer schedules. The resulting 4 cases of DCS which occurred in the first 30 man dives of Phase III was totally unexpected since the shorter Phase II schedule had produced only 1 DCS in 30 man dives. As a result of this high DCS incidence, HVAL12 was developed which kept the same suracing MPTT values as HVAL11 but had the SDR values for the 5, 10 and 20 min tissues reduced. Since both stops of the 120/40 schedule were controlled by the 20 min tissue this lengthened that schedule another 5 min to a total decompression time of 40 min. This was a full 8 min increase over the Phase II HVAL09 schedule. A total of 40 man dives were done on the HVAL12 schedule with no symptoms of DCS (Table 5). All divers who had Type 1 symptoms fom the HVAL11 schedule dove this HVAL12 schedule (Appendix D, Table D-3, Diver #90, 100 and 102). The fourth diver, who had developed Type 2 DCS (#98), reentered the series 5 days later. HVAL12 proved very successful producing only 4 easily treatable Type 1 symptoms of DCS in 309 man dives.

HVAL13 was developed from HVAL12 by increasing the SDR's of the 5 and 10 min tissue to shorten the deeper stops of planned 250 and 300 FSW dives. This empirical shortering of decompression times for these two schedules was simply a calculated guess. HVAL13 resulted in some change in stop time distribution but no change in total decompression time for the 150/30, 160/25, and 180/25 schedules, and only minor shortening of total decompression time for the 160/50, 180/40 and 180/45 schedules (Appendix H). The 250 and 300 FSW schedules proved remarkably safe considering their depth and long decompression times. Of the two cases of DCS which occurred, the one reported as Type 2 may very well have not been DCS at all but a transient postural hypotension. Although the diver had a transient episode of mild syncope 50 min post dive, he rapidly returned to normal just before treatment was begun and had no symptoms other than mild fatigue at that time (Appendix C, Table C-3, diver #97).

Effects of Diving Intensity:

During Phase III testing, some attention was paid to whether or not DCS incidence might increase with a decrease in diving activity. On Friday, August 20 and Monday August 23, 30 man dives were dove each day on a 160/25 schedule (Table 5). The one case of DCS which occurred on the Monday was a

shoulder pain which responded only minimally to recompression and was most likely a muscle sprain. So, this 2 day layoff did not significantly increase the incidence of DCS. After completing dives on August 25, there was a 4 day layoff and on 30 August, 20 man dives on the 160/25 schedule (Table 5) showed no DCS (30 man dives were attempted but one set was aborted because of a computer failure). It appeared that even a 4 day layoff did not change the incidence of DCS, although it is admitted the number of man-dives upon which this conclusion is based is small.

Deep Stop Dives:

The EL-MK 15/16 DCM predicts that tissue offgassing at 20 FSW breathing a 0.7 ATA PO_2 will be the same as at 10 FSW. Also, the MPTT's are such that the surfacing MPTT values could be reached at a 20 FSW stop. The 29 DCS-free dives done during Phase II where the last decompression stop was taken at 20 FSW validated these predictions. Operationally, being able to take the last decompression stop at 20 FSW is useful, especially in heavy seas. Since the total decompression time did not change, after completing the mandatory 20 FSW, one need only remain at any depth between 20 FSW and 10 FSW for the indicated 10 FSW stop time.

At this point, it was felt that HVAL13 could be used to generate a set of operationally useful and safe tables. A complete set of these tables is given in Appendix F. The overall safety of the HVAL13 Tables was estimated as a 3.9% or less expected incidence of DCS (Table 6a). This is essentially the same as the 3.5% expected DCS incidence from development of the constant 0.7 ATA PO_2 in N_2 Decompression Tables (5).

Phase IV Testing

Initial Considerations:

Having developed a computer algorithm which was thought to compute decompression tables of acceptable safety preparations were made to test diving procedures using HVAL13 Tables in the open sea. One of those procedures was an emergency procedure (EP) designed to address the problem of a closed-circuit UBA failure during decompression. Plans called for supplying the diver with compressed air from the surface via an open circuit SCUBA regulator and letting him breathe air during decompression. Since this procedure involves switching inert gas during decompression, it should theoretically speed up decompression. However, in this EP no change in decompression schedule was planned and the dive would continue decompressing on the HeO_2 schedule while breathing air. Two teams of divers, Group A and Group B, were used for Phase IV testing, where this procedure was to be tested. In training for this testing, a 120/40 0.7 ATA constant PO_2 in He decompression schedule was dove by Group A in the OSF using the same real time algorithm as used in Phases I-III. The resultant DCS incidence of 7 cases in 17 man dives was unexpected (Table 7) and Group B did not dive the profile. A complete reevaluation of Phase I-III testing was then begun. In reviewing Phase III testing, it was noted that a similar incident occurred on the HVAL11 120/40 schedule when dove as the first profile of that series (Table 5). In retrospect the large increase in DCS incidence on the 120/40 schedule as the

very first one in Phase III (4 cases in 30 man dives) compared to Phase II (1 case in 30 man dives) may have been due to an increased DCS tolerance in Phase II divers, the so called workup phenomenon.

Workup Phenomenon:

Phase II diving did not start with decompression dives but with 90 man dives on no-decompression dives. Most divers dove every day during the first three days of Phase II, had one day off and then dove again (Appendix D, Table D-2). Based on this diving intensity, it appeared (in retrospect) that the Phase II divers were well worked up by the time decompression dives with higher decompression stress were encountered. Applying these considerations to Phase III testing the 5 min increase in decompression time on the HVAL12 120/40 schedule may have been only partially responsible for the 40 DCS free man dives (Table 5) using that schedule. The other factor may well have been that the HVAL11 120/40 schedule dove as the first Phase III dive provided enough of a workup to increase diver resistance to DCS during the subsequent HVAL12 120/40 schedule testing.

Having postulated that a workup phenomenon was present, the next step was to determine its magnitude and duration. As previously noted, no increase in DCS incidence was noted during Phase III testing even after a 4 day layoff so it was postulated that once a diver was worked up it would take longer than 4 days for the effect to subside. The next problem was to determine how to work up a diver. The Phase II no-decompression profiles did not seem to have resulted in any higher DCS incidence compared to Phase I when dove as the first profiles in Phase II and it appeared that they were sufficient to work up a diver. Based on this consideration, it was decided to see if two less than no-decompression workup dives would be sufficient to decrease the DCS incidence on the 120/40 schedule to acceptably safe levels. The dives selected as workup dives were 80 FSW for 50 min and 100 FSW for 30 min. These choices were somewhat arbitrary but the 80/50 dive was judged to have negligible decompression stress since it was 17 min shorter than the tested no-decompression limit and the 100/30 was judged slightly more stressful being only 2 min shorter than the no-decompression limit (Appendix H, Table H-1).

The plan was to do the two workup dives followed by the 120/40 schedule with no more than 2 days elapsing between each dive. Since it was desirable to test these workup dives with as fresh a group of divers as possible, testing was restarted with Group B divers, who had not dove the initial 120/40 schedule as had the Group A divers. Group B testing was done over 3 consecutive days (Table 7). The initial results looked encouraging with only 1 case of DCS in 16 man dives on the 120/40 schedule. It was surprising that there was a case of DCS on the 80/50 workup schedule but it was an easily treatable Type 1 as was the single case on the 120/40 dive. After an eleven day layoff, which was presumed sufficient time to eliminate any carryover effects from having dove the first 120/40 schedule, Group A reentered the dive series. They began their workup dives with only 14 of the original group remaining and 4 new divers joining the group. Out of the seven divers who got DCS on the first 120/40 dive, five started the subsequent series of workup dives. The results were not as encouraging as the Group B dives. There were two Type 2 DCS during the workup dives and two Type 2 DCS during the final 15 man dives on the 120/40 schedule.

Diver #71 who suffered DCS on the 80/50 Group A workup dive had made 8 dives during Phase II without experiencing DCS, so one could not classify him as a sensitive diver. Diver #11 who suffered DCS on the 100/30 Group A workup dive had not participated in any other phase but did get knee pain on the initial Group A 120/40 dive. Looking at the two divers experiencing DCS on the second Group A 120/40 dive, one (#128) had DCS on the initial Group A 120/40 dive and the other (#125) had no previous DCS. Neither of these divers had participated in earlier phases. Both of these divers went on the Phase V without problems. Diver #120 who suffered DCS on the first Group B 80/50 workup dive switched to Group A and completed all three dives without incident. (This diver did, however, develop a severe Type 2 symptom 7 months later during Phase V [Appendix C, Table C-5]). The distribution of DCS among the Phase IV divers indicated a random occurrence with no identifiable predisposing factors. Even absence of DCS in a previous dive series (Diver #71) did not guarantee avoidance of DCS during Phase IV.

Phase IV results clearly showed a workup phenomenon was present and that even workup dives with bottom times less than no-decompression limits could significantly reduce the incidence of DCS on the 120/40 schedule. However, even with these workup dives the 120/40 schedule attained nowhere near its previous safety record of 40 DCS free dives and it was concluded that the 80/50 and 100/30 sub-no-decompression dives did not provide sufficient workup. Analysis of Phase II dives showed that diving 4 of the HVAL13 no-decompression dives within a 5 day period may have provided sufficient workup for the Phase II decompression dives. During Phase III diving a single 120/40 dive using HVAL13 may have provided sufficient workup for the following 120/40 dive. In Phase IV, whatever workup effect the first 120/40 dive had had for Group A divers was lost afer the 11 day layoff since the DCS incidence in this group was similar to that in the un-worked up Group B divers. Based on this and the Phase III dives done to investigate the effect of diving intensity on DCS as previously discussed, it was concluded that the effects of any workup dives wear off between 5 and 10 days.

This workup phenomenon or adaptation to decompression sickness is not new and has been described in tunnel workers and divers (19, 21). It has also been described in U.S. Navy diving. In 1970, Alexander, Flynn and Summitt (15) set out to test some revisions of the surface-supplied U.S. Navy HeO_2 decompression tables. These revisions had been calculated in 1968 using the method described by Workman (16) and generally required more decompression than the then current tables (which are the tables which currently appear in Volume II of the U.S. Navy Diving Manual). Three revised tables were tested. Twelve man dives done on a 141 FSW/60 min table were DCS free. This table had 15 min less decompression time than the standard HeO_2 decompression table. The next 36 man dives were on revised 196 FSW/60 min and 257 FSW/50 min decompression tables which were about 25% longer than the standard tables. A total of 9 cases of DCS resulted, all reported as Type 1. At this point, no further diving was done. This high incidence of DCS surprised the authors since their analysis showed the DCS incidence in the Fleet to be 0.065-0.83%. The authors did not speculate on the reasons for this unexpectedly high incidence of DCS on the longer revised decompression tables, but one explanation might be that the divers had not been sufficiently worked up.

A more recent unpublished analysis by NEDU of HeO_2 dives done in the Fleet during the period 1968-1983 using the 200 FSW or deeper Surface Helium-Oxygen Partial Pressure Tables showed that 20 cases of DCS occurred in the 147 man dives done with bottom times 30 min or more. There were 4484 man dives with bottom times less than 30 min and only 12 cases of DCS occurred in this group. While it will be admitted that only the deeper HeO_2 schedules were analyzed, the DCS incidence for bottom times 30 min and greater is considerable. No published data is available on the DCS incidence observed during initial testing of the HeO_2 surface-supplied decompression tables but based on the literature cited by Alexander et al (15) it would be expected to be lower than the 13.6% incidence observed since 1968.

In testing of an improved Venturi for the MK V HeO_2 recirculator, Van Der Aue et. al. (18) performed 108 man dives at depths from 225 to 429 FSW resulting in 4 cases of DCS giving an incidence of 3.7%. Bottom times for these dives were generally 20 min. In the above NEDU analysis there were 193 dives done with bottom times of 20 min and there were no cases of DCS reported for these dives. One would conclude, therefore, that the DCS incidence on Surface-Supplied HeO_2 Decompression Tables would rise considerably at bottom times greater than 20 min.

During initial evaluation of the Surface-Supplied HeO_2 Decompression Tables, a DCS incidence approaching 13.6% would undoubtedly have caused the troublesome schedules to be revised. At this point one can only speculate on the reasons for this high incidence of DCS on the deep, long HeO_2 Surface-Supplied Decompression Tables observed since 1968. One explanation is that divers used for initial table testing had been worked up either by previous air diving intensity or from the dives done during the initial table testing. These "worked up" divers then were able to safely dive schedules which would have caused a much higher DCS incidence in "fresh" divers. During the study of Alexander, Flynn and Summitt (15) the divers used were probably "fresh" and thus had not acquired the postulated increased resistance to DCS. The relatively small number of deep HeO_2 dives of 30 min or more bottom time done in the Fleet since 1968 speaks of a relatively low diving intensity and divers who had not had enough recent diving to become "worked up". Clearly, a more thorough analysis of U.S. Navy Fleet diving is necessary before any firm conclusions can be drawn from Fleet diving experience.

Phase V Testing

The results of Phase IV indicated that HVAL13 Tables were safe only for worked up divers and that the two workup dives tried in Phase IV would decrease the incidence of DCS but not to the desired level. Two choices were available at this point; one was to find a workup procedure which would allow HVAL13 schedules to be dove safely and the other was to develop a set of MPTT's which would generate decompression schedules which could be dove by "un-worked up" or "fresh" divers. Since the EOD community tends to dive in isolated areas and many times on short notice, it was decided to take the latter choice and develop a "fresh-diver" MPTT Table. In planning Phase V it was realized from the outset that repeating the 1394 man dives done up to this point was unrealistic and impractical. Since the divers would be getting worked up after their fist dive, testing of more than a few schedules would give little additional information concerning "fresh" divers. So it was

decided to construct a new set of MPTTs then immediately test the 120/40 decompression schedule as the first dive. If that proved safe then two other schedules 200 FSW and deeper would be tested. These deep schedules were chosen because they had been done at the end of the previous phases when the divers were presumably fully worked up and may have appeared safer than they actually were. Finally, the emergency decompression procedure using air initially slated for Phase IV testing would be tested if the HeO_2 schedule testing proved safe.

The subjects for Phase V had only had a total of two 30 FSW for 60 min exposures in the week preceding the dive for training purposes, and had no HeO_2 exposures or dives beyond no-decompression air diving in the two week period before that. The diving schedule was set up to give subjects a minimum two full days off between dives giving a inter-dive period of 60 hours. This intensity was exceeded by only two subjects during the HeO_2 portion of the study; subject #147 dove profile 38 and 43 with only 36 hrs between dives and subject #161 dove profile 38 on two consecutive days (Appendix D, Table D-5).

The initial set of MPTTs developed for Phase V was HVAL16 (Appendix E). Development of HVAL16 began with a reconsideration of no-decompression limits. The Mixed Gas HeO_2 SCUBA Decompression Tables (also called the MK 6 HeO_2 Tables since that was the UBA they were used with) were initially developed using 20% O_2 (17) and later 25% O_2 (12). Up to this point, changing the PO_2 level had been assumed in the EL-MK 15/16 DCM to cause no change in venous oxygen tension. If this is the case then only the tissue inert gas tension need be considered in deriving the MPTT values since changes in arterial O_2 tension would not change tissue O_2 tension. At this point our thinking on this matter was changing and changes in venous PO_2 as a function of arterial PO_2 were being considered for the next version of the EL-MK 15/16 DCM. Also, our thinking was now to consider total tissue gas tension in developing ascent criteria rather than just inert gas tension. Thus, if the PO_2 is raised, a portion of the fall in inert gas tension would be offset by a small increase in venous oxygen tension. When diving a constant PO_2 breathing mix as supplied by the MK 15 or MK 16, there is no variation in arterial oxygen tension so changes in venous PO_2 need not be considered. However, when using the EL-MK 15/16 DCA to compute decompression tables on a constant FO_2 for comparison with existing tables, these venous oxygen level changes must be considered. A PO_2 of 0.7 ATA equals an FO_2 of 25% at 60 FSW. Since the EL-MK 15/16 DCM assumes venous oxygen tension to be constant it should underestimate total tissue tension below 60 FSW using a 25% FO_2 since the model will not raise venous PO_2 in the face of an increased arterial PO_2. Conversely, at depths shallower than 60 FSW the EL-MK 15/16 DCM will overestimate total tissue gas tension since it will not cause the venous oxygen tension to fall as the inspired PO_2 falls. Thus, if the EL-MK 15/16 DCA is used to compute no-decompression limits comparable to the Mixed Gas SCUBA HeO_2 (MK 6) no-decompression limits (13,17), they should be very close at 60 FSW and the EL-MK 15/16 DCA limits should be shorter shallower than 60 FSW and longer deeper than 60 FSW. Table 10 compares the no-decompression limits for HVAL16 and HVAL21 using the EL-MK 15/16 DCA and an FO_2 of 25% with the MK 6 HeO_2 SCUBA tables. At the 170 FSW depth, the no-decompression limit as computed by the EL-MK 15/16 DCA is controlled by the 5 min tissue at an inspired PO_2 of 1.54 ATA. If one postulated an increase in venous oxygen

tension of 0.15 ATA at this depth when the inspired PO_2 increased from 0.70 to 1.54 ATA, and one considers that the MPTTs represent total gas tension instead of inert gas tension only, the no-decompression limit would fall to 10 min. At the shallow end the 50 FSW no-decompression limit is controlled by the 120 min tissue. The PO_2 at 50 FSW is 0.63 ATA and if one postulates a fall of 0.02 ATA in venous O_2 when inspired PO_2 decreases from 0.7 ATA to 0.63 ATA then the 50 FSW no-decompression limit will fall by 1 min to 180 min. This line of reasoning was used to rationalize decreasing the 5 min surfacing MPTT from an HVAL13 value of 120 FSW to 115 FSW in HVAL16 and decreasing the 120 min surfacing MPTT from 50 to 48 FSW. Without these decreases much larger changes in venous oxygen tensions would have had to be postulated in order to reconcile the HVAL16 25% FO_2 no-decompression limits with the MK 6 HeO_2 values. It was also decided to increase the total decompression time for the 120/40 decompression schedule by 10 min and since all stops for this dive would be controlled by the 20 min tissue, its surfacing MPTT had to be reduced from 82 to 77 FSW to obtain the desired increase. The 80 min tissue controlled the 60 FSW no-decompression limit and a value of 55 FSW for the surfacing MPTT gave a limit of 133 min which seemed conservative based on Phase I testing, but which was close to the MK 6 HeO_2 limit.

Initial testing in Phase V began using HVAL16. The SDR's and the 12 FSW increase in MPTT with each 10 FSW depth increase remained the same in HVAL16 as they were in HVAL13. The first 29 man dives on the 120/40 schedule resulted in no DCS and at least the 20 min halftime tissue MPTT adjustment was declared a success (Table 8). All of the 10 min increase in decompression time on this schedule was at the 20 FSW and 30 FSW stop. The next schedule tested was profile #38 which was 200 FSW for 30 min. In spite of a 17 min increase in total decompression time over the HVAL13 profile (Appendix H), there were 2 cases of DCS in 20 man dives, one a bizzare case of retrograde amnesia. This diver had suffered Type 1 DCS previously in Phase IV on the 80/50 workup dive but did complete two other workup dives and an HVAL13 120/40 schedule without problems.

In attempting to lengthen the 200/30 schedule, several techniques were tried. All SDR's for halftime tissues 20 min and longer were decreased to 0.71 which inreased the 200/30 total decompression time 13 min at the 10 FSW stop. Other variations in changing the SDR values were tried but in the end it was decided to keep the HVAL16 SDR's and decrease the MPTT depth increment increase from 12 to 11 FSW producing HVAL21. The resultant 13 min increase in total decompression time on the 200/30 schedule occurred by shifting some stop time deeper and increasing the 10 FSW stop 11 min. This strategy appeared successful and 30 DCS free man dives were done on the 200/30 schedule using HVAL21 (Table 8). The only case of DCS which occurred on HVAL21 was one Type 2 on a 260/22 schedule. This schedule started out as a 300 FSW schedule but an ear squeeze in one of the divers prevented descent below 260 FSW. While his was a Type 2 DCS, the symptoms were mild, easily treatable paresthesias. At this point, no further testing of HeO_2 schedules was done, it was felt that HVAL21 would increase total decompression time sufficiently so that the resultant decompression schedule would be safe for fresh divers.

TABLE 10

25% FIXED FO_2 IN HE NO-DECOMPRESSION LIMITS

No Decompression Times (Min)			
Depth (FSW)	MK 6	HVAL16	HVAL21
40	260	294	294
50	180	181	181
60	130	133	133
70	85	90	91
80	60	60	66
90	45	46	46
100	35	37	37
110	30	30	30
120	25	25	25
130	20	21	21
140	15	18	18
150	15	15	15
160	10	13	13
170	10	11	11
180	5	9	10

HeO_2-Air Emergency Profiles:

In setting out to do the HeO_2-Air Emergency Profiles, it was anticipated that no DCS would occur since the switch from HeO_2 to air should increase tissue offgassing of helium. It should be noted, however, that the PO_2 of all decompression stops shallower than 80 FSW was reduced below 0.7 ATA when air was breathed. This decrease in PO_2 was assumed to be more than offset by the increased offgassing resulting from the change in inert gas but based on the 2 cases of DCS which did occur on these profiles this assumption may have been naive. In testing their revised HeO_2 decompression schedules, Alexander, et. al. (15) used air for decompression during stops from 100 to 40 FSW on a revised 200 FSW partial pressure for 60 min schedule. Two cases of DCS occurred after 6 man dives, the same incidence observed breathing HeO_2 and 100% O_2 during decompression. So even in this early study air breathing was neither detrimental or beneficial. The 2 cases of DCS which did occur during the HeO_2/Air testing were not felt to be of sufficient severity to prevent using air breathing as an emergency procedure.

Decompression Sickness

Of the 174 divers who participated in the 5 phases of this study, 43 suffered decompression sickness at least once. Table 11 shows the frequency of decompression sickness in each of the affected subjects. A total of 11 subjects suffered DCS more than once and of these two subjects had DCS more than 2 times. The means and standard deviations for age, height, weight and percent body fat of the DCS subject population and no-DCS subject population is given at the end of Appendix A. A two tailed t-test was done to see if there was any significant difference between the means of the two populations for any physical characteristics. At the 5% level of significance, the only significant difference between the two populations was mean age which was 28.4 for the DCS population and 30.5 for no-DCS population. Examination of the diving frequency and schedules dove showed no differences between the two populations so all that can be said is that in general the DCS population was younger than the no-DCS population.

Two subjects stand out from all others, accounting for 21% of all DCS. These are subjects #38 who suffered DCS on every one of the 4 dives he made and #40 who suffered DCS 5 times in 22 dives . Both of these subjects could be classified as unusually sensitive to DCS and they tended to be older (38 and 33 yrs) than the 30 yrs population mean, heavier (195 and 212 lbs vs a mean of 178), and had more body fat (26% and 23% vs a mean of 17.5%). Subject #40 suffered DCS on 4 of his first 7 dives in Phase I and appeared to make a full recovery after each one. During the 1 month interval between Phase I and Phase II, this subject paticipated in a series of 25 FSW and 40 FSW 100% O_2 dives without incident. During Phase II he completed 14 DCS free dives then suffered a severe recurrence of Type 2 DCS on the last schedule, which was a 120/40 and HVAL09 (Appendix C, Table C-2). This subject required multiple follow-up treatments but eventually gained full recovery but was disqualified from further diving because of his unusual susceptibility to DCS.

TABLE 11

DECOMPRESSION SICKNESS FREQUENCY

Each entry shows total number of dives dove by each diver and, if DCS occurred, the sequential dive number on which DCS occurred in parenthesis. (Examples: Diver #29 entry of 11(3*,10) means he did 11 dives with DCS occurring on the 3rd and 10th dive).

All DCS Type 1 unless noted with *.

Diver #	Phase I	Phase II @	Phase III	Phase IV	Phase V	DCS Incidence			% DCS
						Type 1	Type 2	Total	
8	5 (5)					1		1	20.0
9	12 (3)					1		1	8.3
12	13	14(2,10)				2		2	7.4
14	13 (8)					1		1	7.7
15	13	13(7*,9)				1	1	2	15.4
17	13 (4)		13 (6)			2		2	7.7
18	11 (4)					1		1	9.1
20	14	13(10*)					1	1	7.5
29	11(3*,10)					1	1	2	18.2
33	4	6 (2)				1		1	10.0
35	7 (7*)						1	1	14.3
38	4(1,2,3,4*)					3	1	4	100.0
40	7(3,4,6*,7*)	15 (15*)				2	3	5	22.3
44	14	15 (5)				1		1	3.4
49		2 (1)				1		1	50.0
56		10(2*,8)				1	1	2	20.0
59		3 (2)				1		1	33.0
61		5 (3)				1		1	20.0
64		11 (8)				1		1	9.1
71		8		2 (2*)			1	1	10.0
72		11 (1)				1		1	9.1
85			13 (6)			1		1	7.7
90			14 (1)			1		1	7.1
97			14 (12*)				1	1	7.1
98			6(1*,6*)				2	2	33.3
100			14 (1)			1		1	7.1
102			15 (1)			1		1	6.7
103			16 (12)			1		1	6.3
104			16 (16)			1		1	6.3
111				3 (1,3*)		1	1	2	66.6
118				2 (1)		1		1	50.0
119				3 (3*)			1	1	33.3
120				4 (1)	2 (2*)	1	1	2	66.6
122				1 (1)		1		1	100.0
123				1 (1)		1		1	100.0
125				4 (4*)	6		1	1	9.1
128				4(1*,4*)	2		2	2	20.0
129				4(1*)			1	1	25.0
130				3	4 (1)	1		1	12.5
137				4 (1)		1		1	25.0
150					4 (3*)		1	1	25.0
155					5 (5)	1		1	20.0
165					3 (2*)		1	1	33.3
TOTALS									
Dives	141	126	121	35	26	--	--	449	
DCS	16	15	10	13	5	37	22	59	13.1%

* TYPE 2 DCS

@ Dives 1-3 of Phase II are no-decompression dives and are tabulated in Table 3 and DCS is described in Table C-1 of Appendix C.

In this dive series, 37% of all DCS was Type 2. This is in contrast to the previously reported N_2O_2 dive series (3,4) where only 17% of symptoms were Type 2 and of these only two (letter key c, r, in Appendix 3, page 3-3 of ref. 3) were of a severity comparable to most of the Type 2 cases here. In the dive series in this report, of the 22 cases of Type 2 DCS, 11 would be considered serious involving the spinal cord, cerebrum and midbrain, 10 less serious involving the spinal cord or perhaps only peripheral nerves and 1 presenting equivocal symptoms. These symptoms are catagorized in Table 12. While many of the symptoms listed as Severe could be referable to the spinal cord, the generalized nature of these symptoms give cause to wonder if they were mainly cerebral manifestations. The symptoms listed as Mild were unlikely to be of cerebral origin and could have been caused by spinal tract lesion or peripheral nerve root involvement.

The randomness and unpredictability of DCS in this dive series is exemplified by the occasional occurrence of severe symptoms in one diver with very mild or no symptoms in his fellow divers. On the 120/40 profile at the end of Phase II, one diver suffered severe Type 2 DCS while 29 others had no symptoms. Another example is from Phase IV where diver #71 became confused and had slurred speech after diving an 80 FSW for 50 min no-decompression profile. Initially, one would put this off as an isolated incident considering the short bottom time but the case of Type 1 DCS which occurred on this profile make this unlikely. The 2 cases of DCS in 35 man dives on this 80/50 sub-no-decompression profile point up the futility of trying to develop profiles which will produce no DCS.

The reason for the high proportion of Type 2 DCS and of cerebral symptoms diving these HeO_2 schedules remains a matter of conjecture. Vann (19) has postulated that the lower solubility of helium allows higher overpressures before gas comes out of solution, but when it does, more bubbles form in a unit tissue volume. One possible prediction is that compared to N_2O_2 breathing, larger numbers of much smaller bubbles form when helium comes out of solution. One could postulate that certain individuals have pulmonary vascular anatomy which would allow many more of these smaller bubbles to cross the lung filter and enter the arterial circulation as tiny gas emboli. (A functionally patent foramen ovale would be another possibility). Once in the cerebral circulation these bubbles would act like arterial gas emboli, and many of the symptom presentations listed in Table 12 did resemble air embolism.

The raw incidence of DCS on the 1503 HeO_2 dives done during the 5 phases of this study was 3.79%. This incidence is much less than the 6.8% raw incidence observed during both phases of N_2O_2 table testing and is similar to the 3.5% expected incidence using the final set of N_2O_2 tables (4). So overall, HeO_2 diving appears to have a lower incidence of DCS than N_2O_2 table but when symptoms do occur there is a higher probability they will be Type 2. The incidence of DCS was 2.5% when air was breathed during decompression but the small number of man-dives (79) done on these schedules makes comparison with the HeO_2 incidence difficult.

TABLE 12

MAJOR SYMPTOMS IN TYPE 2 DCS

	DIVER #	APPENDIX C KEY	MAJOR SYMPTOMS	
			Severe Spinal, Cerebral	Mild, Peripheral Spinal Cord or Equivocal
PHASE I	29	b	Pain, weakness	
	35	f	Weakness, loss bladder control	
	40	i	Weakness, loss proprioception	
	40	g		Aches in back and abdomen
	38	h		Back pain, visual blurring
PHASE II	40	t	Hemiparesis, nausea, loss taste	
	15	n		Paresthesias, pain
	20	p		Paresthesias
	56	k		Paresthesias, pain
PHASE III	98	u	Nausea, vomiting, pain	
	98	w	Vertigo, nausea, tinnitus	
	97	y		Syncope, weakness (?)
PHASE IV	123	aa	Weakness, paresthesia	
	71	bb	Confusion	
	125	dd	Weakness, nausea, vomiting	
	128	dd	Abnormal balance and mentation	
	128	aa		Ulnar nerve paresthesia, hand weak
	129	aa		Back tightness, paresthesias
	111	cc		Low back pain
PHASE V	120	gg	Retrograde amnesia	
	165	hh		Paresthesias
	150	ii		Paresthesias

(?) Equivocal symptom which may not have been DCS. See text.

Treatment of Decompression Sickness:

All cases of DCS were treated with standard U.S. Navy Treatment Table 5 or 6 with five exceptions. Diver #120, (Appendix C, Table C-5) was compressed to 165 FSW and treated on a modified Treatment Table 4 when he showed little improvement with initial compression to 60 FSW. Modifications included breathing a 50/50 N_2O_2 mix at 165 FSW and during decompression to 60 FSW. Immediately upon arrival at 60 FSW, the diver was given several periods of 100% O_2 breathing for 25 min interspersed with 5 min air breaks until his symptoms abated over the next few hours.

Four divers were kept at 60 FSW for 10-18 hours (Appendix C; Table C-1, Diver #35; Table C-2, Diver #40; Table C-4, Divers #123, #71). Diver #71 had been compressed to 165 FSW after only partial improvement at 60 FSW and was decompressed back to 60 FSW on a Treatment Table 4 schedule where he was kept for 12 hours. The three other divers were all initially treated by compression to 60 FSW. At 60 FSW, these divers were given 100% O_2 by mask for 25 min periods followed by 5 min. air breaks as indicated by their symptoms. This was usually done for a maximum of 4 hours (8 -O_2 breathing cycles) at which point a 4-hour air breathing period was begun. Only subject #40 got significant symptoms of pulmonary oxygen toxicity because of the large number of O_2 breathing periods given.

The decompression schedule used to decompress the four divers at 60 FSW after their extended stay, as shown in Appendix C, was a 30 hour schedule developed during a series of 60 FSW air saturation dives done at NEDU. The 30 hour schedule used here was successful at decompressing both the diver and the tender who breathed only air throughout the treatment. Further testing at NEDU has shown that while the 30 hour schedule is sufficient for 18-24 hour bottom times, a 36 hour schedule is required for 96 hour stays at 60 FSW and, in fact, may be more suitable for a treatment table. This 36 hour schedule uses the same three rates as the 30 hour schedule except that the rate is changed at 40, and 20 FSW instead of at 30 and 10 FSW. This extended 60 FSW treatment table has been incorporated into Revision 1 of Vol. 1 of the U.S. Navy Diving Manual as Treatment Table 7. Full details of how treatments should be conducted are given in the new revision to the U.S. Navy Diving Manual and the development of the 60 FSW air saturation decompression schedule will be the subject of a future NEDU report.

With the exception of the modified Treatment Table 4, the only breathing gases used for treatments was air and oxygen. Although all dives were done breathing HeO_2, there was no observed adverse effect from compressing on air while breathing oxygen. All divers showed some improvement or complete relief on initial compression, no symptoms were exacerbated once treatment was begun. There were two notable relapses of symptoms after apparent initial resolution. These were Diver #35 (Appendix C, Table C-1) and Diver #40 (Appendix C, Table C-2), both of who suffered recurrence of serious central nervous system symptoms requiring extended treatment. Even in these cases, however, complete resolution of symptoms was eventually obtained using air treatment tables.

Returning to Diving After Treatments:

Divers successfully treated for Type 1 DCS were allowed to resume diving 48 hours after treatment. Divers suffering Type 2 DCS were kept off diving

for variable lengths of time depending on the severity of their symptoms and response to treatment. Generally, those divers suffering symptoms listed as Mild in Table 12 resumed diving 4 to 6 days after treatment. Of the 11 divers listed in Table 12 suffering Severe symptoms, eight did no further diving after treatment for that symptom (35, 40t, 98w, 123, 71, 125, 128dd, 120). Diver #29 was off 8 days then resumed diving and suffered a Type 1 DCS after completing 6 symptom-free dives. Diver #40(i) was off 6 weeks after his first severe symptom and completed 14 symptom-free dives before suffering another severe Type 2 symptom which eliminated him from the study. Diver #98(a) responded promptly to initial treatment and resumed diving 4 days later, completed 3 symptom-free dives then suffered another Type 2 DCS and did no further diving.

It appears that a 48 hour period of no diving after successful treatment of Type 1 DCS is sufficient for the vast majority of divers. Two divers in this series (#38 and #40) showed themselves abnormally sensitive to DCS and will be discussed separately. Of the other 41 subjects, only 9 suffered DCS more than once (12, 15, 17, 20, 56, 98, 111, 120, 128). Of these, only two divers had Type 2 DCS twice. Diver #98 had less than the 4-6 day layoff after his first Type 2 symptoms (Appendix D, Table D-3) but Diver #128 had 10 days off after his first symptom. The seven other subjects showed no particular predilection for DCS and their second bout of DCS was usually preceded by several DCS-free dives and in two cases (Divers #17 and #120) the 2 DCS incidents occurred on separate dive series.

Divers #38 and #40 presented special problems and have been discussed earlier in this section. Diver #38 had extended off periods between his three Type 1 symptoms (3 days, 5 days and 11 days) before suffering a Type 2 symptom. He suffered DCS on every dive and it appeared that no period of time off from diving would have been sufficient for this remarkably sensitive individual. Diver #40 was off 3 days and 4 days after his two initial symptoms which were both Type 1. His third DCS occurred after only one symptom-free dive, 8 days after his previous Type 1 DCS treatment. The Type 2 component of this third bout of DCS was back and abdominal aches which responded very rapidly to minimal recompression and he was given 6 days off before resuming diving at which time he suffered another Type 2 symptom involving muscle weakness and loss of proprioception. Again he responded rapidly to treatment but did no further dives during Phase I. This diver was then a subject on 100% O_2 dives to depths from 25 to 40 FSW and this activity plus the 6 week hiatus between HeO_2 dive series lead to the conclusion that more than sufficient time had elapsed for complete resolution of any sub-clinical residual effects of DCS. The ensuing 14 symptom-free dives this diver did over the next 4 weeks of Phase II initially reinforced this conclusion and the severe Type 2 DCS he suffered on the last dive of Phase II was totally unexpected. It was concluded that this diver had an abnormally high predilection for DCS from HeO_2 dives and should do no further diving.

The sensitivity of subjects #38 and #40 to DCS cloud the issue of how much time should be taken off after DCS occurs. As previously noted, 48 hours after successful treatment of a Type 1 DCS symptom appears a sufficient non-diving interval. Based on the response of divers #98 and #128, it appears a longer period of time should have elapsed after their Type 2 symptoms before they resumed diving. While a 5 to 6 day layoff appeared sufficient for most other divers in this series who suffered Type 2 symptoms, a 14 day non-diving

period after suffering Type 2 DCS would appear more reasonable for widespread use in operational diving. This recommendation must be caveated by saying that the symptom should have responded promptly to a Treatment Table 6 and had complete relief. Divers suffering symptoms such as those described as Severe in Table 12 should probably have even longer non-diving periods up to 4 weeks. However, as shown by diver #40, even this may not be sufficient in sensitive individuals and individuals who show an abnormally high incidence to DCS (whether Type 1 or Type 2) should probably be eliminated from further diving as soon as this increased incidence becomes apparent.

Final Decompression Tables

The HVAL21 Tables shown in Appendix G are the final set of tables computed by the EL-MK 15/16 DCA resulting from this study. Tables are given in feet of sea water (FSW) with 10 FSW stops and in meters of sea water (MSW) with 3 MSW stops. Ascent and descent rates for tables in feet are 60 FSW/min. The Royal Navy descent and ascent rates of 20 MSW/min (or 1 meter every 3 sec) were used for the metric tables. The EL-MK 15/16 DCA uses pressures in FSW internally so all depths were first converted to FSW using the conversion factor 0.3048 MSW/FSW (5). The limit line shown in each group of tables define the depth/time limits of the EL-MK 15/16 DCM. The depth and bottom time increments which were used to construct the tables were those felt to be the most useful operationally. Since the tables are computed using the EL-MK 15/16 DCA, tables for any depth and bottom time combinations could be computed if that were desirable.

Table Safety:

The tables shown in Appendix G should prove safe for even un-worked up divers and are the ones being recommended for Fleet use. The overall raw incidence of DCS for all HeO_2 dives using all HVAL's in this study was 3.79% which was almost half of the raw incidence for all schedules tested using a N_2O_2 breathing medium (4), and which is similar to the 3.5% expected incidence for N_2O_2 Tables falling within the final model limits (4). Since all tables computed using HVAL21 are longer than HVAL13 Tables, one could justifiably add the 1135 man dives and 36 cases of DCS from dives falling within HVAL13 limits (Table 6a) to all of the 109 man dives and 3 cases of DCS done during Phase V HeO_2 decompression schedule testing to get an overall estimate of 4.0% for the expected incidence on HVAL21 Tables assuming a binomial distribution at the 95% confidence level. Thus, even with only these minimal selection criteria, the HVAL21 Tables have established approximately the same safety record after testing as had the previously tested N_2O_2 Tables (4).

While testing of HVAL21 itself comprised only 109 man dives in Phase V, further testing would not have been beneficial because once the divers became worked up then the shorter HVAL13 Tables would have proven safe. Rather, the true safety of HVAL21 Tables is attested to by 29 DCS free dives at a depth/time combination known to produce a high DCS incidence on fresh divers using HVAL13. The no-decompression limits have been reduced to approximate those of the MK 6 HeO_2 schedules which have proved remarkably safe in Fleet use, and the decompression times have been increased substantially over the HVAL13 schedules. Comparison of the 0.7 ATA profiles with the MK 6 SCUBA profiles is difficult but the 60/170 schedule on HVAL21 is 6 min longer than

the corresponding MK 6 schedule and the 80 FSW for 90 min HVAL21 schedule is just 2 min shorter than the MK 6 schedule. Considering the much higher PO_2 breathing 0.7 ATA PO_2 during decompression compared to a 25% HeO_2 mix, these HVAL21 Tables should prove much safer than the current Helium-Oxygen SCUBA Decompression Tables currently being used by the Fleet.

Once divers have become worked up they could dive the HVAL13 Tables. It would appear that 4 no-decompression dives over a 5 day period would be sufficient to work up divers. However, until considerable Fleet experience is gained with HVAL21 Tables and this work up phenomenon is better quantitated through testing, HVAL13 Tables are not recommended for Fleet use.

The high proportion of DCS in this HeO_2 series which were Type 2 has led to a very conservative approach in developing operational tables. The increase in decompression time in HVAL21 Tables over HVAL13 Tables is one manifestation of that approach. Another is the way diving will be done in the Fleet. Instead of using 100% He as a diluent gas as was done in these dives, an HeO_2 mix will be used. Since additional oxygen will be added to the breathing loop during descent the initial PO_2 in the UBA will be well above the 0.75 ATA mean observed in this study during the first several minutes on the bottom. Also, when the MK 16 was designed, it had a set point of 0.7 ATA with a low O_2 alarm at 0.4 ATA. Since testing of these profiles was done on a MK 15 which has a low O_2 alarm at 0.6 ATA, the low O_2 alarm on the MK 16 had to be raised to that level. In doing this the set point had to be raised to 0.75 ATA. So when diving these tables with the MK 16 UBA, an additional degree of safety is introduced.

The emergency procedure using air was successful enough during testing that it too is recommended for Fleet use. This means that in the event of a UBA failure during decompression, the diver can switch to air breathing at any point in the decompression profile and continue to follow the appropriate HVAL21 Table to the surface. After using this procedure the diver should be observed but does not have to be treated unless signs of DCS arise. This emergency procedure was used during the open sea dives described below on a 300 FSW dive without incident. Also, Phase II testing (Profile 30D) has shown that the 10 FSW stop can be taken at 20 FSW or any depth between 10 FSW and 20 FSW if desired. For metric tables the 3 MSW stop can be taken at 6 MSW or any depth in between.

No repetitive diving was done during these dive series and testing of the EL-MK 15/16 DCM on repetitive dives will be necessary before repetitive diving tables can be calculated. This testing will be necessary before the EL-MK 15/16 DCM could be used in an Underwater Decompression Computer for multiple level and repetitive diving. At present, the EL-MK 15/16 DCM using HVAL21 is most useful in computing single depth dive tables.

Rules For Using Tables:

The rules for using the decompression tables given in Appendix G were formulated based on the present testing and previous N_2O_2 testing (3,4). While primarily designed for use with the MK 15 or Mk 16 UBA, the tables can be used with any electronically controlled constant PO_2 UBA with a set point

of 0.7 ATA or higher. However, in order to be consistent with the methods used in testing these tables, the UBA should warn the diver if the PO_2 falls to 0.6 ATA and the diver should take action to raise the PO_2 back to 0.7 ATA at that point. The limit line concept was used so that schedules could be dove right to the limits of the tested depth/time domain and there would be sufficient back up schedules for emergencies or other unforseen circumstances. While no repetitive dive testing was done, rules for considering dives dove within the previous 12 hour period were developed. The choice of a 12 hour "clean dive" time was based on the apparent success of this time in air repetitive diving and in the presumption that helium will offgas at a much faster rate at 1 ATA breathing air than will nitrogen. In addition, since the no-decompression limits for these tables are longer than the air limits and since breathing helium seems to keep decompression time about the same or less than when breathing N_2O_2 (4), it seemed reasonable to be able to compute a residual nitrogen time for use with subsequent air tables using the maximum depth ever attained and the sums of all bottom times for all dives done within the past 12 hours. These rules are felt to be very conservative but are the best that can be developed without the necessity for further man-testing. These rules were developed to give the necessary flexibility for using these tables in the operational environment and will be changed as experience is gained.

HVAL 21 Tables, as shown in Appendix G, were dove on 13 man dives in the open sea from a 19' inflatable rubber boat during testing of MK 16 deployment procedures. Depths of the dives were from 180 FSW to 300 FSW and no symptoms of DCS were noted despite seas ranging 16-18 FSW wave height and water temperatures down to 37°F (20).

Relevance To Saturation Decompression:

As a final point, the EL-MK 15/16 DCM using HVAL21 needs to be discussed in the context of HeO_2 saturation diving. As discussed earlier, consideration was given to the HeO_2 decompression rates and upward excursion limits in determining the 120 min MPTTs and the rate at which these MPTT values are increased with increasing depth. When MPTTs were increased 10 FSW for each 10 FSW of depth increase and an SDR of 1.0 was used the mean offgassing rate breathing a 0.4 ATA (13.2 FSW) PO_2 was:

$$dP/dT = K \cdot (2.8-PO_2) = [\ln(2)/120] \cdot (2.8 - 13.2) = - 0.0601 \text{ FSW/min}$$

or

$$dP/dT = - 3.61 \text{ FSW/Hr}$$

HVAL21 calls for losing 11 FSW of inert gas to ascend 10 FSW and in addition has an SDR of 0.83 for the 120 min tissue giving a mean offgassing rate of:

$$(10/11) \cdot (0.83) \cdot (-3.60) = -2.72 \text{ FSW/hr}$$

This appears slower than presumably safe saturation decompression rates so HVAL21 will predict extremely conservative saturation decompression rates. The surfacing MPTT for the 120 min tissue is 48 FSW and at a PO_2 of 0.4 ATA

this represents saturation at a depth of 28.2 FSW. In reviewing the NEDU diving logs, Duffner, et.al. (17) found that Van Der Aue exposed 6 divers to a depth of 33 FSW on HeO_2 (assumed to be 20% O_2) for 36 hours and surfaced them without incidence. At that depth the PO_2 is 0.4 ATA so predicting a no-decompression saturation limit of 28.2 FSW appears to be on the conservative side. Reducing the MPTT depth increment increase to 11 FSW per 10 FSW depth increase will also decrease the predicted saturation upward excursion limits. So in the end the reconciliation with HeO_2 saturation data had to be compromised in order to obtain a reasonable set of bounce diving tables.

Overall, the most important parameter in HeO_2 decompression tables appears to be the total decompression time. Stop depth distribution appears important insomuch as shallower stops should be longer than deeper stops but there is no evidence that small variations in stop depth distribution are important. Thus, in further refining the EL-MK 15/16 DCM, retaining total decompression time will be more important than the actual stop depth distribution. It remains to be seen if the EL-MK 15/16 DCM can eventually be modified to compute both bounce and saturation HeO_2 tables. One major issue remaining to be resolved is how venous oxygen tension varies with changes in arterial oxygen tension. Resolution of this issue is necessary if any decompression model is to be used to compute tables of widely varying inspired oxygen tensions.

CONCLUSIONS

1. Tables computed with the EL-MK 15/16 DCA using HVAL21 are safe and recommended for operational use.

2. HVAL21 Tables can be dove taking the 10 FSW stop at 20 FSW (or 3 MSW stop at 6 MSW for metric tables).

3. Air can be breathed during decompression on HVAL21 Tables without table modification.

4. The EL-MK 15/16 RTA using HVAL21 cannot be used for multiple level or repetitive diving without further testing.

5. A powerful workup phenomenon exists which increases a divers' resistance to DCS as he continues to dive.

6. A diver can get worked up by diving 4 no-decompression HeO_2 profiles over a 5 day period.

7. A diver will stay worked up over a 4 day period without diving but will lose his increased resistance to DCS some time between 5 and 10 days.

8. Further investigation and quantitation of the workup phenomenon observed during this study is necessary before it can be used operationally.

9. Tables computed by the EL-MK 15/16 RTA using HVAL13 can only be safely dove by worked up divers.

10. The overall incidence of DCS diving constant 0.7 ATA PO_2 decompression schedules using HeO_2 was less than diving N_2O_2 but a higher proportion of DCS breathing HeO_2 is Type 2.

11. There is a wide individual variation in susceptibility to DCS and severe symptoms may occur even on apparently low decompression stress dives.

12. Further modification of the MK 15/16 DCM is necessary before it can be used to compute tables with wide variations in inspired PO_2 and nitrogen levels.

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APPENDIX A

DIVER PHYSICAL CHARACTERISTICS

DIVER PHYSICAL CHARACTERISTICS

SUBJECT #	PHASE	AGE (yrs)	HEIGHT (inches)	WEIGHT (lbs)	SKINFOLD(mm) TRI	SS	SI	(Note 1) % FAT
1	I II	35	72	165	11	12	21	21.5
2	I II IV V	26	68	150	7	7	5	8.9
3	I II	43	73	195	12	13	24	26.2
4	I II IV	34	69	175				
5	I II	23	75	177	7	11	7	12.1
6	I II	38	72	173	11	20	20	23.0
7	I II	38	70	155	5	10	5	13.3
8 *	I	30	69	170	9	22	8	20.2
9 *	I	37	73	210	12	30	21	25.3
10	I II	31	67	155	11	10	8	17.1
11	I II	38	75	195	9	17	21	22.2
12 *	I II	21	68	158	9	8	8	12.1
13	I II	31	66	150	12	13	21	21.9
14 *	I	22	74	175	4	10	9	11.1
15 *	I II	26	74	191	9	14	7	14.2
16	I	20	72	160	6	10	8	11.6
17 *	I III	28	68	160	13	18	14	19.0
18 *	I II	21	69	176	6	7	7	9.5
19	I II V	36	69	154	4	11	3	12.2
20 *	I II	26	69	163	13	11	15	17.3
21	I II	25	69	174	4	13	6	11.1
22	I	27	72	175	5	12	9	12.5
23	I	34	75	185	18	11	9	19. 9
24	I	38	71	188				
25	I	28	71	189	18	26	27	24.5
26	I II	36	64	189	9	23	17	22.6
27	I							
28	I II	24	68	140	6	6	4	7.0
29 *	I	26	72	210	7	11	7	12.1
30	I II	34	66	158				
31	I	32	71	196	12	19	9	20.5
32	I II	26	69	165	23	10	22	21.4
33 *	I II	32	72	167	6	9	6	13.8
34	I	31	70	164	8	17	15	20.5
35 *	I	29	72	175	7	13	8	13.4
36	I IV	32	72	203	11	22	21	23.7
37	I	29	66	140	9	10	5	11.6
38 *	I	38	69	195	21	24	22	26.0
39	I II V	24	72	190	13	15	12	17.6
40 *	I II	33	74	212	12	19	18	22.6
41	I II	21	75	181	14	18	14	19.2
42	I	21	64	125	11	7	9	13.0
43	I II	24	69	143	6	9	5	9.5
44 *	I II	30	73	215	10	26	23	24.6
45	I	21	69	170	13	13	9	16.0
46	I	24	71	155	7	11	7	12.1
47	I II IV	28	74	198	13	13	13	17.3

(Continued)

*Divers who suffered decompression sickness symptoms.

DIVER PHYSICAL CHARACTERISTICS (Cont.)

JECT	PHASE	AGE (yrs)	HEIGHT (inches)	WEIGHT (lbs)	SKINFOLD(mm) TRI	SS	SI	(Note 1) % FAT
	II	38	73	195	18	20	16	23.7
*	II	38	72	188	15	17	25	24.2
	II	24	68	150	12	11	7	14.2
	II	33	73	227	17	23	33	26.9
	II	28	69	176				
	II IV	44	68	140	9	10	11	19.4
	II III	41	72	165	13	12	20	25.0
	II	35	71	185	13	12	11	19.4
*	II	23	70	180	17	16	17	20.2
	II	27	71	170	8	10	11	13.8
	II	27	68	174	16	21	23	22.4
*	II	32	72	210	28	14	24	25.8
	II	40	69	175	23	23	23	31.2
*	II	28	73	222	12	22	34	23.9
	II IV	28	73	190	11	15	17	18.4
	II	33	71	195	20	15	25	24.8
*	II	23	72	150	18	8	7	15.3
	II	36	75	210	15	16	25	24.0
	II	30	70	167	9	13	14	19.4
	II	33	70	175	16	11	19	21.9
	II IV	28	70	196	16	24	23	23.0
	II	42	72	188	12	15	25	27.1
	II IV	35	68	175	7	14	17	19.9
*	II IV	40	72	195	13	18	20	26.8
*	II	21	72	180	9	10	8	13.0
	II	33	69	190	26	22	40	28.9
	II	39	68	150	9	10	11	17.4
	II	26	73	198	14	18	27	22.2
	II IV	27	69	170	9	14	16	17.3
	II IV	35	71	153	7	7	10	15.1
	III	24	68	172				
	III	37	68	146				
	III	40	72	201				
	III	25	68	162				
	III	25	70	190				
	III	27	74	195				
	III	28	72	176				
*	III	32	69	150				
	III	32	70	160				
	III	34	69	165				
	III	31	71	160				
	III	29	71	180				
*	III	22	72	166				
	III	23	69	182				
	III	27	68	171				
	III	42	73	213				
	III	29	69	170				

(Continued)

ers who suffered decompression sickness symptoms.

DIVER PHYSICAL CHARACTERISTICS (Cont.)

SUBJECT #	PHASE	AGE (yrs)	HEIGHT (inches)	WEIGHT (lbs)	SKINFOLD(mm) TRI	SS	SI	(Note 1) % FAT
95	III	28	68	155				
96	III	24	70	165				
97 *	III	21	72	155				
98 *	III	27	76	218				
99	III	31	71	176				
100 *	III	25	70	176				
101	III	37	72	217				
102 *	III	22	71	192				
103 *	III	21	71	205				
104 *	III	22	73	175				
105	III V	23	69	175	4	13	10	13.0
106	III	34	70	185				
107	III	26	69	155				
108	III	26	73	168				
109	III	23	70	150				
110	III	25	37	235				
111 *	IV	29	68	160	13	13	7	15.3
112	IV	34	76	180	9	9	4	14.2
113	IV	33	72	174	12	14	7	18.4
114	IV	37	67	170	19	19	9	22.2
115	IV	36	69	155	12	20	15	22.2
116	IV	30	72	172	6	9	5	13.3
117	IV V	44	69	150	7	11	5	15.7
118 *	IV	26	70	205	16	13	13	18.2
119 *	IV	39	70	187				
120 *	IV V	28	72	195	11	28	15	21.2
121	IV V	24	75	175	9	10	5	11.6
122 *	IV	38	71	185	12	12	12	19.4
123 *	IV	24	71	163	17	8	5	14.2
124	IV V	33	78	250	10	20	12	21.0
125 *	IV V	25	70	155	3	2	8	4.6
126	IV	35	71	170	12	12	12	19.4
127	IV	30	68	163	13	14	9	19.4
128 *	IV V	30	73	200	17	22	8	22.2
129 *	IV	30	72	180	10	14	7	17.8
130 *	IV V	34	69	170	12	18	11	20.7
131	IV	31	73	185	8	13	5	16.0
132	IV	42	73	205	14	17	13	24.7
133	IV	26	71	195	9	12	11	14.9
134 (F)	IV	29	62	132	18	14	19	29.4
135	IV	39	69	170	9	14	8	17.8
136	IV	32	71	203	20	29	13	25.1
137 *	IV	26	68	164	7	9	6	10.6
138	IV	37	69	182	10	23	8	20.7
139	V	35	71	161	12	11	8	17.8
140	V	31	73	224	10	13	7	17.4
141	V	30	73	190	6	12	8	16.0
142	V	33	69	168	9	13	7	17.1

(Continued)

* Divers who suffered decompression sickness symptoms.
F Female

DIVER PHYSICAL CHARACTERISTICS (Cont.)

SUBJECT #	PHASE	AGE (yrs)	HEIGHT (inches)	WEIGHT (lbs)	SKINFOLD(mm) TRI	SS	SI	(Note 1) % FAT
143	V	21	71	190	10	11	7	13.4
144	V	30	71	170	9	8	6	14.7
145	V	32	72	190	11	18	8	19.6
146	V	34	67	160	6	8	4	12.2
147	V	25	68	168	8	12	4	11.6
148	V	23	73	183	5	9	3	7.7
149	V	32	72	215	9	9	5	14.7
150 *	V	31	72	188	16	11	3	17.4
151	V	22	68	156	11	12	5	13.4
152	V	23	72	161	9	11	6	12.5
153	V	27	65	157	7	15	4	12.5
154	V	33	75	195	12	11	4	16.4
155 *	V	37	69	164	12	12	7	17.8
156	V	28	72	165	5	8	3	7.0
157	V	34	68	172	13	21	5	20.2
158	V	27	71	185	18	15	6	17.3
159	V	26	73	198	11	21	7	17.3
160	V	37	65	153	12	15	5	18.1
161	V	29	75	192	9	11	3	11.1
162	V	30	70	170	8	11	6	15.6
163	V	27	71	225	14	20	11	19.0
164	V	24	72	164	5	9	3	7.7
165 *	V	28	67	154	11	14	4	13.8
166	V	31	69	176	13	14	5	18.1
167	V	27	73	200	19	9	6	15.7
168	V	26	69	181	7	9	3	8.9
169	V	29	76	220	10	17	5	14.9
170	V	30	76	190	7	11	4	14.2
171	V	28	71	185	10	13	5	13.4
172	V	26	70	157	7	11	4	10.6
173	V	31	72	175	12	16	8	19.4
174	V	29	72	186	8	9	5	10.6

MEANS $

All Subjs.	Mean	30.0	70.5	178.0		17.5
	s.d.	5.7	3.6	21.2		5.3
	N	173	173	173		136
* Subjs. with DCS	Mean	28.4	71.0	181.6		17.8
	s.d.	5.7	2.0	20.5		5.5
	N	43	43	43		34
Subjs. without DCS	Mean	30.5	70.3	176.8		17.5
	s.d.	5.6	4.0	21.4		5.3
	N	130	130	130		102

(Continued)

* Subjects who suffered decompression sickness symptoms.

$ N reflects number of subjects with entries in table for particular physical characteristic.

DIVER PHYSICAL CHARACTERISTICS (Cont.)

Note 1: Body fat percentage computed from triceps (TRI), subscapular (SS), and supra-iliac (SI) skinfolds according to the method of;

Durnin, J.V.G.A., and J. Womersley, Body Fat Assessed from Total Body Density and Its Estimation from Skinfold Thickness: Measurements on 481 Men and Women Aged from 16 to 72 Years. British Journal of Nutrition 32:77-97, 1974.

APPENDIX B

HANDLING NITROGEN IN THE MK 15/16 DCM WITH A HELIUM DILUENT

APPENDIX B

HANDLING NITROGEN IN THE MK 15/16 DCM WITH A HELIUM DILUENT

EL-MK 15/16 Decompression Model (DCM) assumes that all inert gas in a given compartment exchanges at the same rate, that is it is a single inert gas model. In doing surface oriented HeO_2 diving the diver will initially be saturated with nitrogen and will also have a lung full of nitrogen. When he goes on the fixed PO_2 UBA, the total inert gas tension will not exceed 0.3 ATA (since the PO_2 is controlled to 0.7 ATA) and of this a certain fraction will be nitrogen and the rest helium. The nitrogen in the UBA will always have a lower partial pressure than that initially in the tissues and the diver will offgas nitrogen throughout the dive and eventually reach an equilibrium where the nitrogen partial pressure in the UBA breathing loop and body is the same and no further nitrogen exchange takes place. In developing the 0.7 ATA fixed PO_2 in He MPTT tables, they were adjusted to produce safe decompression schedules under the conditions tested which included a lung full of nitrogen (all divers were in fact instructed to inhale to the end of a normal inspiration before going on the UBA). The adjustment to the MPTT values presumably compensated for any nitrogen present in the body and the final set of MPTT's actually reflect total inert gas tension some of which is nitrogen. But, while the EL-MK 15/16 DCM described here works for closed-circuit UBA's using an HeO_2 diluent it might not work for trimix diving or diving where switches between helium and nitrogen inert gas is made. What follows is a brief discussion of the considerations which must be made when extrapolating this model to other conditions.

Gas Uptake

When dealing with more than one inert gas the following equation describes exponential uptake:

$$(1) \qquad P_{IN} = P_{N_2} + P_{He}$$

$$= P_{A_{He}} - (P_{A_{He}} - P_{I_{He}}) \cdot e^{-K_1 \cdot T} + P_{A_{N_2}} - (P_{A_{N_2}} - P_{I_{N_2}}) \cdot e^{-K_2 \cdot T}$$

where:

P_{IN} = total inert gas tension

P_{N_2}, P_{He} = tissue nitrogen and helium tension

$P_{A_{N_2}}$, $P_{A_{He}}$ = arterial nitrogen and helium tension

$P_{I_{N_2}}$, $P_{I_{He}}$ = initial tissue tension

K_1 = helium time constant

K_2 = nitrogen time constant

Note that the sum $P_{N_2} + P_{He}$ is the total inert gas tension, P_{IN}, which is what the EL-MK 15/16 RTA computes every 2 seconds. The EL-MK 15/16 DCM basically assumes that all gas other than O_2, CO_2 and water vapor is a single inert gas with tension P_{IN}. This is eqivalent to saying that $K_1 = K_2$ and if this is done, equation (1) becomes:

$$(2) \qquad P'_{IN} = P_{A_{He}} + P_{A_{N_2}} - [(P_{A_{He}} + P_{A_{N_2}}) - (P_{I_{He}} + P_{I_{N_2}})] \cdot e^{-K_1 \cdot T}$$

and since, $P_{A_{He}} + P_{A_{N_2}} = P_{A_{IN}}$ and $P_{I_{He}} + P_{I_{N_2}} = P_{I_{IN}}$, then:

(3) $$P'_{IN} = P_{A_{IN}} - (P_{A_{IN}} - P_{I_{IN}}) \cdot e^{-K_1 \cdot T}$$

which is the gas exchange equation used by the EL-MK 15/16 DCM.

If K_1 is not equal to K_2 then there will be an error in computing total inert gas tension, the magnitude of which is found by subtracting equation (1) from equation (2):

$$E = P_{IN} - P'_{IN} = (P_{A_{N_2}} - P_{I_{N_2}})(e^{-K_2 \cdot T} - e^{-K_1 \cdot T})$$

OR

(4) $$E = C\,(e^{-K_2 \cdot T} - e^{-K_1 \cdot T})$$

Since this error is time dependent, its value will go through a maximum. At T=0 and when T is very large, E will be 0. To find the maximum, equation (4) is differentiated and the time at which the derivative of zero is found:

$$dE/dT = C[-K_2 \cdot e^{-K_2 \cdot T} + K_1 \cdot e^{-K_1 \cdot T}] = 0$$

OR

(5) $$K_1/K_2 = (e^{-K_2 \cdot T})/(e^{-K_1 \cdot T}) = e^{(K_1 - K_2) \cdot T}$$

Now let $K_1/K_2 = r$, then equation (5) reduces to:

$$r = e^{(r-1) \cdot K_2 \cdot T}$$

and solving for T:

(6) $$T = \ln(r)/[(r-1)\cdot K_2]$$

Substituting this time back into equation (4):

$$E_{max} = C_{max} \cdot \left\{e^{-\{\ln(r)/(r-1)\}} - e^{-\{[K_1\cdot\ln(r)]/[K_2\cdot(r-1)]\}}\right\}$$

or since $K_1/K_2 = r$

(7) $$E_{max} = C_{max} \cdot \left\{e^{-\{\ln(r)/(r-1)\}} - e^{-\{[r\cdot\ln(r)]/(r-1)\}}\right\}$$

This equation reduces to:

$$E_{max} = C_{max} \cdot \left\{e^{\{\ln(r)\cdot[-1/(r-1)]\}} - e^{\{\ln(r)\cdot[-r/(r-1)]\}}\right\}$$

OR

(8) $$E_{max} = C_{max} \cdot \left\{r^{-[1/(r-1)]} - r^{-[r/(r-1)]}\right\}$$

where: E_{max} = maximum error

C_{max} = maximum value of $(P_{A_{N_2}} - P_{I_{N_2}})$

The value of r is the ratio of helium and nitrogen time constants which is the product of blood flow per unit volume times the ratio of blood gas solubility to tissue gas solubility. Values for solubilities of nitrogen and helium taken from Buhlmann (Decompression-Decompression Sickness. Springer-Verlag, New York, 1984) in ml/ml at 1 ATA are:

Gas	Blood	Olive Oil	Blood/Olive Oil Ratio
N2	12.831	66.129	0.194
He	8.886	15.693	0.566

The maxmum value for the ratio of the blood/olive oil ratios for the two gases is 0.566/0.194 or 2.92 which should also be the ratio of N_2 to He halftimes. This value should then be the maximum value for r since the blood flow per unit volume will be he same for each compartment no matter what inert gas is present. In developing his decompression tables, Buhlmann has assumed a value of 2.65 for the ratio of N_2 to He halftimes. The following are values of E_{max} for various values of r:

r	E_{max}
1.00	0
1.5	$0.15 \cdot C_{max}$
2.0	$0.25 \cdot C_{max}$
2.65	$0.34 \cdot C_{max}$
2.92	$0.38 \cdot C_{max}$

The largest value for C_{max} should occur at the beginning of the dive with the body initially saturated with 0.79 ATA of nitrogen and the UBA level around 0.3 ATA (see UBA Oxygen, Carbon Dioxide and Nitrogen Section of main

text) giving a value of C_{max} of 0.49 ATA or 16.2 FSW. Assuming a worst case value for r of 0.38, the maximum error estimate would be -6.1 FSW.

Gas Elimination

The above analysis is for gas uptake. The situation for offgassing is the same if it is exponential but in the EL-MK 15/16 DCM offgassing is usually linear:

(9) $$P = P_I - (P_V - P_A) \cdot K$$

Using an analysis similar to that above, it can be shown that the error in computing inert gas elimination is:

$$E_{o_{max}} = -(P_{A_{N_2}} - P_{V_{N_2}}) \cdot (K_2 - K_1)$$

OR

(10) $$E_{o_{max}} = -C_{max}[K_2 \cdot (1-r)]$$

For a given value of r the maximum error will be for the shortest halftime tissue. Values for $E_{o_{max}}$ for different halftime tissues and values of r are:

	$E_{o_{max}}$	
r	$T_{1/2}$ = 5 min	$T_{1/2}$ = 120 min
1	0	0
1.5	$0.07 \cdot C_{max}$	$0.0029 \cdot C_{max}$
2.0	$0.14 \cdot C_{max}$	$0.0058 \cdot C_{max}$
2.65	$0.23 \cdot C_{max}$	$0.0095 \cdot C_{max}$
2.92	$0.27 \cdot C_{max}$	$0.0111 \cdot C_{max}$

For the faster tissues the maximum error will be about the same as the error made during gas uptake, but for slower tissues the error will be one third of that for gas uptake.

Since nitrogen is always offgassing, C_{max} is negative and the value for E_{max} and $E_{o_{max}}$ will always be negative, meaning that the single gas model will underestimate the total inert gas tension compared to a double inert gas model. As time goes on the difference between $P_{A_{N_2}}$ and $P_{I_{N_2}}$ will decrease and the errors will get smaller.

Since the EL-MK 15/16 DCM was tested with divers initially saturated on air, the tissue halftimes and MPTT values are not really pure helium values but are He/N_2 values. If the HeO_2 version of the EL-MK 15/16 RTA is used for other than closed-circuit diving, as described in this report, then extrapolation of the present single inert gas model may not work. Taking into account the above considerations a more rigorous double inert gas model will have to be constructed if repetitive diving breathing air during 1 ATA surface intervals is to be addressed.

APPENDIX C

DECOMPRESSION SICKNESS DESCRIPTIONS

TABLE C-1

DECOMPRESSION SICKNESS DESCRIPTIONS

PHASE I AND PHASE II NO-DECOMPRESSION DIVES

Table 3 Key	Diver #	Date Mod	Profile FSW/Min	DCS Type and Location	Onset Time Post Dive	Comments
a	38	1/21/82 HVAL01	160/11	(1) L. shoulder.	5 min	Complete relief at 47 FSW on compression, Treatment Table 5.
b	29	1/23/82 HVAL02	100/41	(2) Nausea, generalized weakness, skin mottling, pain L. Scapula.	1 min	Complete relief after 10 min at 60 FSW, Treatment Table 6.
	40			(1) L. shoulder.	2 min	Complete relief after 20 min at 60 FSW, Treatment Table 6. (Treatment Table 6 extended one O_2 period at 60 FSW to accommodate diver #9 Treatment Table 5 below.)
	9			(1) L. shoulder.	60 min	Complete relief upon arrival at 60 FSW, Treatment Table 5.
c	17	1/25/82 HVAL02	100/41	(1) L. shoulder.	1 min	Complete relief at 45 FSW on compression, Treatment Table 5.
	18			(1) Sterno-clavicular joint.	1 min	Complete relief at 30 FSW on compression, Treatment Table 5.
d	38	1/25/82 HVAL02	140/15	(1) Hips, costo-vertebral joints, costo-chondral junctions.	4 min	Hip pain gone by 5 min at 60 FSW. All other symptoms gone upon arrival at 60 FSW. Treatment Table 5.
e	40	1/27/82 HVAL03	100/35	(1) Bilat. severe hip pain.	5 min	Complete relief at 30 FSW on compression, Treatment Table 5.
f	38	2/1/82 HVAL03	120/25	(1) L. shoulder, ribs.	1 min	Complete relief by 6 min at 60 FSW, Treatment Table 5. Repeat treatment for residual soreness 10 hrs later with no changes at 60 FSW. Residual soreness not considered DCS.
	8			(1) Low back pain L4/L5 inter-vetebral joints, no radiation.	8 min	Previous history of low back pain. Had mild low back pain on previous dive which was untreated but resolved. This pain in same area but more intense. Complete relief at 40 FSW on compression, Treatment Table 5.
	35			(1) L. scapula, rhomboid, deltoid, and costochondral region (pains non-radiating).	5 min	Had been lifting weights day before dive resulting in some mild pectoralis soreness. Complete relief at 17 FSW on compression, Treatment Table 5. Two hrs post treatment
				(2) Leg weakness, paresthesias, and inability to urinate.	5 hrs	Two hrs post treatment developed leg weakness and paresthesias progressing to inability to urinate. Compressed to 60 FSW for 30 hrs. Received Decadron, 10 mgm initially, then 4 mgm q.i.d. (i.m.). Gradual improvement in leg strength over 30 hrs stay. Decompressed in 30 hrs as follows: 60→30 FSW, 3 FSW/hr; 30→10 FSW, 2 FSW/hr; 10→0 FSW, 1 FSW/hr. Upon surfacing on 2/4/82 had residual leg weakness and incomplete bladder emptying on urination. Started on Bethanecol 10 mgm q.i.d. for bladder tone. Over the next week had five Treatment Table 6's at which point treatments were stopped when no further improvement noted after 2 consecutive treatments. Bladder showed only slight residual urine after urination, legs had very mild weakness. Over next week began lifting weights and running. 30 days later, cystometrogram showed normal bladder function. Only mild leg symptoms (weakness and decreased agility) noted with hard physical activity (e.g. touch football). Only objective neurological signs, very slight decrease in R. wrist and L. foot and toe dorsiflexors when compared to other sides. Completely normal 1 month later. Resumed normal diving activity on air in May 82. Began training for serious running in June. Two years later only subjective problem was 3 min increase in 10K running time to 37 min. Has been air diving since May 82 to 200 FSW without any problems.

(Continued)

TABLE C-1 (Cont.)

DECOMPRESSION SICKNESS DESCRIPTIONS

PHASE I AND PHASE II NO-DECOMPRESSION DIVES

Diver #	Date Mod	Profile FSW/Min	DCS Type and Location	Onset Time Post Dive	Comments
14	2/5/82 HVAL04	120/22	(1) L. shoulder.	12 min	Started as ache in pectoralis muscles, R>L which decreased 15 min post dive. 10 min later pain in L. shoulder occurred. Complete relief at 26 FSW on compression, Treatment Table 5.
40			(2) L. shoulder pain followed by aches in back and abdomen.	5 min	Complete relief at 32 FSW on compression, Treatment Table 6.
38	2/12/82 HVAL05	60/147	(2) L. shoulder pain, back pain, visual blurring	3 min	Complete relief on arrival at 60 FSW Treatment Table 6.
40	2/12/82 HVAL05	120/20	(2) Bilat. upper & lower extremity weakness. Weak L. toe flexors. Loss of proprioception lower extremities.	20 min	Never had pain, crainial nerves WNL. Complete relief after 10 min at 60 FSW, Treatment Table 6.
29	2/17/82 HVAL05	100/34	(1) R. elbow.	40 min	Complete relief at 33 FSW on compression, Treatment Table 5.
56	3/30/82 HVAL06	100/32	(2) Pain and paresthesia L. lateral thigh.	40 min	Complete relief on arrival at 60 FSW on compression, Treatment Table 6.
33			(1) R. shoulder.	30 min	Complete relief at 20 FSW, treated with above diver (#56), Treatment Table 6.
12	3/31/82 HVAL06	200/6	(1) R. & L. shoulder.	1 min	Complete relief within 10 min at 60 FSW, Treatment Table 5.

TABLE C-2

DECOMPRESSION SICKNESS DESCRIPTIONS

PHASE II DECOMPRESSION DIVES

Table 4 Key	Diver #	Date Mod	Profile FSW/Min	DCS Type and Location	Onset Time Post Dive	Comments
m	44	4/6/82 HVAL07	200/30	(1) R. subpatellar region.	4 hrs	Complete relief after 10 min at 60 FSW, Treatment Table 5.
n	15	4/9 HVAL07	100/105	(2) R. knee pain, R. hip pain, L. thorax pain, paresthesia, leg & thigh.	2.5 hrs	Complete relief after 12 min at 60 FSW, Treatment Table 6.
o	49	4/12 HVAL07	100/105	(1) L. knee.	2 hrs	Complete relief at 30 FSW on compression, Treatment Table 5.
p	15	4/19 HVAL07	140/60	(1) L. knee.	3 hrs	Complete relief at 30 FSW on compression. Treatment Table 5.
	20			(2) Paresthesia R. thigh, tightness of R. hip & knee.	6 hrs	Symptoms developed overnight. Reported next day for treatment Relief after second 02 period. Treatment Table 6.
q	64	4/21 HVAL07	180/45	(1) R. knee.	3 hrs	Complete relief upon arrival at 60 FSW, Treatment Table 5.
	12			(1) R. shoulder.	10 min	Complete relief upon arrival at 60 FSW, Treatment Table 5.
	56			(1) R. shoulder. L. shoulder, bilat. hip.	70' Stop 1 min	Diver pulled R. shoulder on bottom producing sharp pain lasting few min. Pain noticeable at 70 FSW stop. Very noticeable at 10 FSW stop. Other symptoms occurred after surfacing. Complete relief on arrival at 60 FSW, Treatment Table 6
	72			(1) Wrist, knee, ankle.	13 hrs	Complete relief after 20 min at 60 FSW, Treatment Table 6.
r	61	4/23 HVAL09	180/45	(1) Bilat. knee. (resolved spontaneously). (1) Recurrence knee pain.	1 min 4 hrs	Bilat. knee pain noted post dive but resolved. 4 hrs post dive went running with recurrence of knee ache. 5 hrs post dive knee ache increased and got worse again with hot shower. Complete relief upon arrival at 60 FSW, Treatment Table 5.
s	59	4/27 HVAL09	150/30	(1) R. shoulder.	10 min	Complete relief upon arrival at 60 FSW, Treatment Table 5.
t	40	4/28 HVAL09	120/40	(2) R. shoulder pain. Bilat. hip and upper extremity weakness. R. sided weakness, nausea, vomiting, loss taste on ant. tongue, intercostal and diaphragm weakness, L. side decreased sensation to light touch and pinprick.	10' Stop 5 min 5 hrs	Shoulder symptoms noted 2 min before leaving 60 FSW stop. Completed 120/40 schedule before surfacing. Other symptoms developed after surfacing. Complete neuro exam after compression to 60 FSW normal. Felt fatigued throughout treatment. Complete relief upon arrival at 60 FSW, Treatment Table 6. After completing Treatment Table 6, diver left chamber and appeared normal. During post treatment physical became nauseated and vomited. Rapid onset of R. sided weakness ensued. Noted change in taste on ant. 2/3 tongue (postulated mid brain lesion). Compressed to 60 FSW within 10 min of symptom onset with slight improvement. Kept at 60 FSW 36 hrs, decompressed in 30 hrs as follows: 60→30 FSW, 3 FSW/hr; 30→10 FSW, 2 FSW/hr; 10→0 FSW, 1 FSW/hr. Strength improved at 60 FSW with O_2 breathing. O_2 stopped because of severe insp. pain (O_2 tox.). Surfaced on 2 May with R. arm and leg weakness, decreased spotty R. sided light touch and pinprick deficits, decreased taste sensation ant. 2/3 tongue, PFT's decreased to 33-50% normal. Pain of O_2 tox. prevented further treatment till 2 wks later. Static lung pressure measuements showed decreased (50% normal) insp. and exp. max. pressures. Most of PFT decrease probably due to intercostal muscle and diaphragm weakness. Next week received a total of 5 treatments (3-4 hrs) at 30-40 FSW on 100% O_2. Would not tolerate O_2 deeper than 40 FSW. Some improvement in strength and paresthesias. Treatment stopped because no further improvement noted on last 2 treatments. Three weeks later had decreased strength only noted in running and athletic activities, dyspnea after running 1/2 mile and on immersion. Regained full function by Dec 82 with no further treatments. Disqualified from diving but continues sport diving without problems.

TABLE C-3

DECOMPRESSION SICKNESS DESCRIPTIONS

PHASE III DECOMPRESSION DIVES

Table 5 Key	Diver #	Date Mod	Profile FSW/Min	DCS Type and Location	Onset Time Post Dive	Comments
u	98	8/5/82 HVAL11	120/40	(2) Nausea, vomiting, L. knee pain.	2 hrs	Complete relief on arrival at 60 FSW, Treatment Table 6.
	100			(1) R. knee.	2 hrs	Complete relief on arrival at 60 FSW. Treated on Table 6 with above diver (#98).
	90			(1) R. knee.	1 hr	Complete relief on arrival at 60 FSW, Treatment Table 5.
	102			(1) R. shoulder.	2 hrs	Complete relief at 10 min at 60 FSW, Treatment Table 5.
v	85	8/16/82 HVAL11	100/90	(1) Bilat knee.	1 min	Symptoms initially present on surfacing. L. knee resolved in 1.5 hrs but R. knee pain persisted. Treatment began 1.5 hrs post dive. Complete relief at 53 FSW on compression, Treatment Table 5.
	17			(1) R. knee.	1 min	Symptoms reported and treated 1.5 hrs post dive. Complete relief upon arrival at 60 FSW. Treatment Table 5.
w	98	8/18/82 HVAL11	60/70	(2) Vertigo, nausea, diaphoresis. Decreased hearing, tinnitus (abnormal audiogram).	80 min 12 hrs	Complete relief after 18 min at 60 FSW, Treatment Table 6. Compression to 60 FSW took 10 min because of trouble equalizing. Complete relief after 12 min at 60 FSW. (Normal audiogram post treatment). Treatment Table 6.
x	103	8/23/82 HVAL11	160/25	(1) L. deltoid muscle at humeral insertion.	1 min	Noted slight pain only with movement post dive. Improved with hot shower but increased overnight. Reported 20 hrs post dive for treatment with pain and stiffness in shoulder. Stiffness gone at 60 FSW, pain mild and only in certain positions. Treatment Table 5.
y	97	8/25/82 HVAL11	250/25	(2) Syncope, weakness, fatigue.	50 min	Returned to normal just before treatment started except for fatigue. Neuro on arrival at 60 FSW WNL except for mild mailaise. In retrospect may have been postural hypotension unrelated to decompression sickness. Treatment Table 6.
z	104	9/1/82 HVAL13	300/10	(1) R. shoulder.	15 min	Complete relief upon arrival at 60 FSW, Treatment Table 5.

TABLE C-4

DECOMPRESSION SICKNESS DESCRIPTIONS

PHASE IV DIVES

Table 7 Key	Diver #	Date Mod	Profile FSW/Min	DCS Type and Location	Onset Time Post Dive	Comments
aa	111	9/8/83 HVAL13	120/40	(1) L. knee.	6 hrs	Complete relief on arrival at 60 FSW. Treatment Table 5.
	118			(1) Bilat. knee.	12 hrs	Complete relief on arrival at 60 FSW. Treatment Table 5.
	122			(1) L. hand.	90 min	Generalized hand discomfort with flexing. Complete relief after 10 min at 60 FSW. Treatment Table 5.
	123			(2) Generalized weakness, L. leg paresthesia.	8 hrs	Symptoms progressed rapidly over 30 min after first being noticed. Improvement of symptoms after 2 extensions of Treatment Table 6 at 60 FSW. Decided to keep at 60 FSW until symptoms resolved. Complete relief afer 10 hrs at 60 FSW. Decompressed as follows: 60÷30, 3 FSW/hr; 30÷10 FSW, 2 FSW/hr; 10÷0 FSW, 1 FSW/hr.
	128			(2) Ulnar nerve paresthesia, slightly decreased grip strength.	8 hrs	Symptoms began suddenly. Complete relief after 10 min at 60 FSW. Treatment Table 6.
	129			(2) Back tightness, paresthesias R. lat. forearm, little finger.	9 hrs	Treated 12 hours post dive. Complete relief after 2 min at 60 FSW, Treatment Table 6. Diver did not consider symptoms DCS until he made a 15 FSW pool dive next day and noted lessening of symptoms at which time he reported for treatment.
	137			(1) L. shoulder ache.	10 min	Symptoms very mild and resolved in 10 min leaving very mild residual soreness which subsided in 24 hrs. Not considered DCS initially, DCS in retrospect. Not treated.
bb	71	9/19/83 HVAL13	80/50	(2) Confusion, slurred speech, decreased grip strength.	2 hrs	Only partial relief after 2 hrs at 60 FSW. Compressed to 165 FSW with complete relief after 10 min. After 2 hrs at 165 FSW decompressed to 60 FSW on Treatment Table 4 schedule. Kept at 60 FSW 12 hrs then decompressed as follows: 60÷30, 3 FSW; 30÷10 FSW, 2 FSW/hr; 10÷0 FSW, 1 FSW/hr.
cc	111	9/22/83 HVAL13	100/30	(2) Severe low back pain, girdle pain, leg weakness.	5 min	Complete relief upon arrival at 60 FSW, Treatment Table 6. Residual flank and calf soreness next day. No change after 20 min at 60 FSW, decompressed on Treatment Table 5 but symptom not considered DCS.
dd	128	9/23/83 HVAL13	120/40	(2) Loss of balance, dulled mentation, positive Rhomberg to L.	110 min	For 2 min after onset of Symptoms had to be held erect. After that could walk but not with completely normal gait. Complete relief after 20 min at 60 FSW. Treatment Table 6.
	125			(2) Weakness progressing to nausea and vomiting. R. leg weakness and R. ant. lat. thigh hypoesthesia.	90 min	Nausea resolved at 30 FSW during decompression. Remainder of symptoms gone after 3rd O_2 period at 60 FSW. Treatment Table 6 with one extension at 60 FSW.
ee	120	9/13/83 HVAL13	80/50	(1) Bilat. knee pain.	15 hrs	Complete relief at 10 min at 60 FSW. Treatment Table 5.
ff	119	9/15/83 HVAL13	120/40	(1) R. knee, L. shoulder.	60 min	Complete relief after 5 min at 60 FSW. Treatment Table 5.

TABLE C-5

DECOMPRESSION SICKNESS DESCRIPTIONS

PHASE V DECOMPRESSION DIVES

Table 8 Key	Diver #	Date Mod	Profile FSW/Min	DCS Type and Location	Onset Time Post Dive	Comments
gg	120	4/12/84 HVAL16	200/30	(2) Retrograde amnesia, confusion.	90 min	Diver appeared normal after dive. At 80 min post dive was found wandering facility and could not remember having dove or where he was. Neuro exam, except for memory symptoms, normal. Compressed to 60 FSW with little improvement over 20 min on 100% O_2. Compressed to 165 FSW and put on 50/50 N_2-O_2. Gradual improvement over next 2 hrs. Decompressed to 60 FSW on Treatment Table 4. Given complete battery of neuropsychological test on arrival at 60 FSW which were normal at that time. Treatment Table 4.
	130			(1) L. knee.	8 hrs	Relief after 10 min at 60 FSW, Treatment Table 5.
hh	165	4/17/84 HVAL21	260/25	(2) Bilat. medial ankle paresthesias.	12 hrs	Improvement after 10 min at 60 FSW. Complete relief after 3 O_2 periods. Treatment Table 6.
ii	150	4/23/84 HVAL21 AIR STOPS	100/60 (He/ air)	(2) L. shoulder pain. L. arm paresthesia. L. elbow paresthesia.	10 min 45 min 60 min	Previous history of L. shoulder injury. Complete relief after 20 min at 60 FSW, Treatment Table 6.
jj	155	4/26/84 HVAL21 AIR STOPS	80/90 (He/ air)	(1) L. elbow.	24 hrs	24 hrs after dive noted mild, intermittent elbow pain. 4 days later pain worsened on a commercial airplane flight. Two weeks after that presented himself for treatment with intermittent pain and questionable paresthesias. Complete relief within 10 min at 60 FSW, Treatment Table 5.

APPENDIX D

INDIVIDUAL DIVING INTENSITY

TABLE D-1

PHASE I INDIVIDUAL DIVING INTENSITY

Body of Table Shows Profile No. (Table 1; Appendix H)

Diver No.	January 1982						February 1982								Diver No.
	21	22	23	25	27	29	1	5	8	10	12	15	17	19$	
1					11	35a									1
2			12	2	11	35a			18		18			17N	2
3									5		10				3
4				12		35a		5	5	10	2			17N	4
5	11	2	35a@	12	11	20	20	19	5	23	10	18	2	17N	5
6						35a									6
7	11	2	35a	12	11	20	20	19	5			18	2	17N	7
8	11	2	35a	12			20*								8
9	1	29	12*		11	20	20		18	10	2	18	10	17N	9
10	1	12	2@	24	11	35a	20	5	18	10	2	18	10	17N	10
11											10				11
12	1	12	2	24	11	20	20	5	18	10	2	18		17N	12
13						35a						18	10	17N	13
14	11	2	35a	12	11	20	20	19*	5	23		18	2	17N	14
15	11	2	35a	12	11		20	19	5	23	10	18	2	17N	15
16	1	12	2	24@	11		20	5	18	10	2				16
17	11	2	35a	12*	11	20	20	19		23	10	18	2	17N	17
18	11	2	35a	12*	11			19	5	23	10	18	2		18
19										23	18	18	10	17N	19
20	11	2	35a	12	11	20	20	19	5	23	10	18	2	17N	20
21	1	12	2	24@	11	20	20	5	18	10	2	18	10	17N	21
22	1	12	2	24	11	35a	20	5	18	10		18	10	17N	22
23	1	12	2	2	11	35a	5	19	18	23	18	2	10	17N	23
24												18	10	17N	24
25	1	12	2	24	11	35a	20	5	18	23		18	10	17N	25
26						35a@									26
27						35a									27
28	1	29	12	2	11	35a	5	19	18	23	18	2	10	17N	28
29	1	29	12*				5	19	18	23	10	2	10*	17N	29
30							20								30
31											10				31
32						35a@	5					18		17N	32
33					11							2	10	17N	33
34	1		12	2	11		5	19	18	23	18	2	10	17N	34
35	1	12	2	24	11	35a	20*								35
36										10	2	2	10		36
37	11	2	35a				20	19	5	23	10	18		17N	37
38	1*			24*			20*				2*				38
39		2	35a	2	11	35a		19	18	23	18	2	10	17N	39
40	1	29	12*		11*		5	19*			18*				40
41								5	18	23					41
42	1	29		2											42
43	1	29	12	2	11	35a	5	19	18	23	18	2	10	17N	43
44	1	29	12	2	11	35a	5	19	18	23	18	2	10	17N	44
45	1	29	12	2	11	35a	5	19	18	23	18	2	10	17N	45
46	1	12	2	24	11	20	20	5	18	10	2	18	10	17N	46
47								19				18	2	17N	47

@ Did Not Complete Dive

* Decompression Sickness

$ Profile 17N are N_2O_2 Dives Reported in NEDU Report 1-84. They are not included in dive statistics in this report.

TABLE D-2

PHASE II INDIVIDUAL DIVING INTENSITY

March-April 1982

Body of Table Shows Profile No. (Table 1; Appendix H)

No-Decomp.			HVAL07															HVAL09				Diver
9(d)	30	31	2	5	6	7	8	9	12	13	14	15	16	19	20	21	22	23	26	27	28	No.
														25		34		34		26	21	1
			36	38		28		16		38(D)		22				34	13	13	37	26	21	2
	9		36																	26	21	3
									16				25				13					4
7	9	35	36																			5
		35	36																			6
7	9	35	36	38		27				38(D)		22			22		13	13	37	26	21	7
7	9	35	36	38		27		15	38(D)		22				22		13	13	37	26	21	10
		35																		26	21	11
7		35*	36		38		28		16		38(D)		25	25		34*		34	37	26	21	12
7	9	35	36			28		15		38(D)		22										13
7	9	35	36	38		28		15*			22			25*		34@	13	34			21	15
7	9	35	36	38						38(D)		22		25		34	13		37	26	21	18
						27														26	21	19
7	9	35	36		38		28		16		38(D)		25	25*					37	26	21	20
7	9	35	36		38		28		16		38(D)		25						37	26	21	21
7	9	35												25				34				26
7	9	35	36	38				15	38(D)		22				22						21	28
7	9	35	36											25		34	13					30
					38		28															32
7	9*															34			37	26	21	33
7	9	35	36	38		28		15		38(D)				25					37	26	21	39
7	9	35	36	38		27		15	38(D)		22				22		13	34	37	26	21*	40
				38		27		15			22						13	13	37	26	21	41
7	9	35	36	38		28		15		38(D)		22		25		34	13					43
7	9	35	36		38*		28		16		38(D)		25	25		34		34	37	26	21	44
			36																37			47
				38		27													37	26		48
									16*		38											49
7	9	35	36	38		27		15	38(D)		22				22		13	13	37	26	21	50
7	9	35	36		38		28		16		38(D)			25		34		34	37			51
7	9	35	36							38(D)		22						13	37	26		52
7	9	35	36																	26	21	53
7	9		36	38		28		15				22		25		34	13		37	26	21	54
						28								25		34	13		37		21	55
7	9*				38		28		16			22		25		34*			37		21	56
7	9	35	36	38		27		15	38(D)		22				22		13	13	37	26	21	57
				38		28		15														58
											22									26*	21	59
					38		28												37			60
				38													13	34*	37		21	61
									38(D)			22			22							62
				38				15						25					37	26		63
7	9	35		38		28		15		38(D)						34*		13	37	26		64
														25								65
									38(D)				25	25		34						66
7	9	35	36											25		34		34	37	26		67
7	9	35	36					15								34	13	34	37	26	21	68
		35	36			28								25			13				21	69
								15	38(D)		38(D)		25									70
7	9	35						15		38(D)			25		22		13					71
7	9	35	36		38		28		16		38(D)		25		22	34*						72
									38(D)			22		25		34						73
				38		27		15								34			37	26		74
7	9	35	36	38		27		15	38(D)		22				22		13	13	37	26	21	75
									16		38(D)		25				13	13				76
					38		28												37	26	21	77

lot Complete Dive
pression Sickness
Stop 20 FSW

TABLE D-3

PHASE III INDIVIDUAL DIVING INTENSITY

August-September 1982

Body of Table Shows Profile No. (Table 1; Appendix H)

Diver No.	HVAL11	HVAL12													HVAL13						Diver No.
	5(d)	6	7	9	10	11	12	13	16	17	18	19	20	23	24	25	30	31	1	2	
17	21	21	21		33	7			14*			31		30	39	40	30	42		42@	17
54	21	21	21	33		7		6		3	31		30								54
78	21	21	32	33		7	14	6		3	31			30	39	40	#	42	44		78
79	21		21	33		7		6		3	31		30		39	40		42	44	42	79
80	21	21		33		7	14			3	31		30	30	39		#	42	44		80
81	21	21	32		33			6		3		31	30	30	39	40	30	42	42	44	81
82	21	21			33	7		6	14	3		31	30	30	40		30	42		44	82
83	21	21	21	33			14	6	14	3	31		30	30	39	40	#	42	44		83
84	21	21	32	33		7	14	6		3	31		30	30	39	40	#	42	44		84
85		21	32		33	7		6	14*			31	30		39	40	30	42		44	85
86	21	21		33	32		7	6	14		3	31	30	30	40		30	44	42	42	86
87	21	21	21	33		7	14	6					30	30	39	40	#	42	44		87
88		21	32		33	7		6					30	30	39	40	30	42		44	88
89	21	21	21	33			14	6		3	31	31	30	30	39	40	#	42		44##	89
90	21*		21		33	7		6	14	3		31	30	30		40@	30	42		44	90
91		21	32			7	14	6		3	31		30	30	39		#	42	44		91
92	21	21	32	33	32		7	6	14		3	31	30	30	40		30	44	42	42	92
93	21	21	32			7		6	14	3		31	30	30	39	40		42		44	93
94	21	21	32			7		6					30	30	39	40	30	42		44	94
95	21	21	32	33	32		7	6	14		3@			30	40		30	44	42	42	95
96		21	32	33	32				14		3	31	30	30	40		30	44			96
97	21	21	21			7	14	6		3		31	30	30	39	40*	#		44		97
98	21*				32		7	6	14		3*										98
99		21	21	33		7	14			3	31		30	30	39	40	#	42	44		99
100	21*		21	33		7	14	6		3	31		30	30		40	#	42	44		100
101	21	21	32	33	32		7	6		3				30	40		30	44		42	101
102	21*		21		33	7		6	14	3		31	30	30	39	40	30		42	44	102
103	21	21	32	33	32		7	6	14		3	31	30	30*			30	44	42	42	103
104	21	21	32	33	32		7	6	14		3	31	30	30	40		30	44	42*		104
105	21	21	32		33			6	14	3		31	30	30	39	40	30			44	105
106	21	21	32		33	7			14	3		31	30	30	39	40	30	42		44##	106
107	21	21			33	7		6	14	3		31	30		39	40		42		44	107
108	21	21	32	33	32		7	6	14		3	31	30	30	40		30	44	42	42	108
109	21	21	32	33	32		7	6	14		3	31	30	30	40		30	44	42	42	109
110	21	21	32	33			7	6	14		3	31	30	30	40		30	44	42	42	111

@ Did Not Complete Dive
* Decompression Sickness
# Aborted Dive to 160 FSW - Computer Failure
No Exercise
d date

TABLE D-4

PHASE IV INDIVIDUAL DIVING INTENSITY

September 1983

Profile (FSW/MIN) Shown Below Date

Diver No.	Group A 9/8/83 (120/40)	Group B 9/13 (80/50)	Group B 9/14 (100/30)	Group B 9/15 (120/40)	Group A 9/19 (80/50)	Group A 9/22 (100/30)	Group A 9/23 (120/40)	Diver No.
2		∘	∘	∘				2
4	∘				∘	∘	∘	4
36	∘				∘			36
47					∘	∘	∘	47
53		∘	∘					53
62		∘	∘	∘				62
68		∘	∘	∘				68
70	∘				∘	∘	∘	70
71	∘				*			71
76		∘	∘	∘				76
77		∘	∘	∘				77
111	*				∘	*		111
112		∘	∘	∘				112
113	@				∘	∘	∘	113
114		∘	∘	∘				114
115	∘				∘	∘	∘	115
116		∘	∘	∘				116
117	∘							117
118	*				∘			118
119		∘	∘	*				119
120#		*			∘	∘	∘	120#
121	∘				∘	∘	∘	121
122	*							122
123	*							123
124					∘	∘	∘	124
125	∘				∘	∘	*	125
126		∘	∘	∘				126
127		∘	∘	∘				127
128	*				∘	∘	*	128
129	*				∘	∘	∘	129
130		∘	∘	∘				130
131					∘	∘	∘	131
132		∘	∘	∘				132
133	@					∘	∘	133
134#	∘		∘	∘				134#
135	∘				∘	∘	∘	135
136		∘	∘	∘				136
137	*				∘	∘	∘	137
138		∘	∘	∘				138

Completed Dive
Did Not Complete Dive
Decompression Sickness
Dove in Group A & B

TABLE D-5

PHASE V INDIVIDUAL DIVING INTENSITY

April 1984

Body of Table Shows Profile No. (Table 1; Appendix H)

Diver	HVAL16			HVAL21				HVAL21 He02/Air					Diver
No.	9(d)	10	12	13	16	17	19	20	23	24	26	27	No.
2	21				38				46			46	2
19					38		43		46		45	45	19
39	21		38			38				47	45		39
105			38			41			46				105
117	21												117
120	21		38*										120
121	21		38				43		46		45		121
124		21											124
125	21		38			41		47		47	45		125
128				38			43						128
130			38*			41			46		45		130
139		21				38		47		47		46	139
140	21		38			41					45		140
141	21		38			41			46		45		141
142			38				43		46		45		142
143				38			43			47		46	143
144	21				38		43		46				144
145		21		38			43			47		46	145
146							43			47		45	146
147	21					38	43		46		45		147
148	21				38		43				45		148
149	21								46				149
150			38			41			46*			45	150
151		21		38			43			47		46	151
152		21		38		41						45	152
153				38			43					45	153
154	21				38		43		46			46	154
155		21			38			47		47	45*		155
156	21		38			38		47			45		156
157			38			41			46		45		157
158	21		38				43		46				158
159			38									46	159
160		21				41		47		47		46	160
161					38	38		47	46			46	161
162	21		38			38		47	46		45		162
163				38			43					45	163
164	21		38			38		47	46		45		164
165			38			41*						46	165
166	21		38				43				45		166
167	21@		38			38		47	46		45	45	167
168			38			38		47					168
169		21			38		43			47	45		169
170		21		38			43					46	170
171		21			38		43						171
172	21				38				46		45		172
173				38			43					45	173
174				38		38			46		45		174

@ Did Not Complete Profile
* Decompression Sickness
d date

APPENDIX E

MAXIMUM PERMISSIBLE

TISSUE TENSIONS (MPTT) TABLES

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

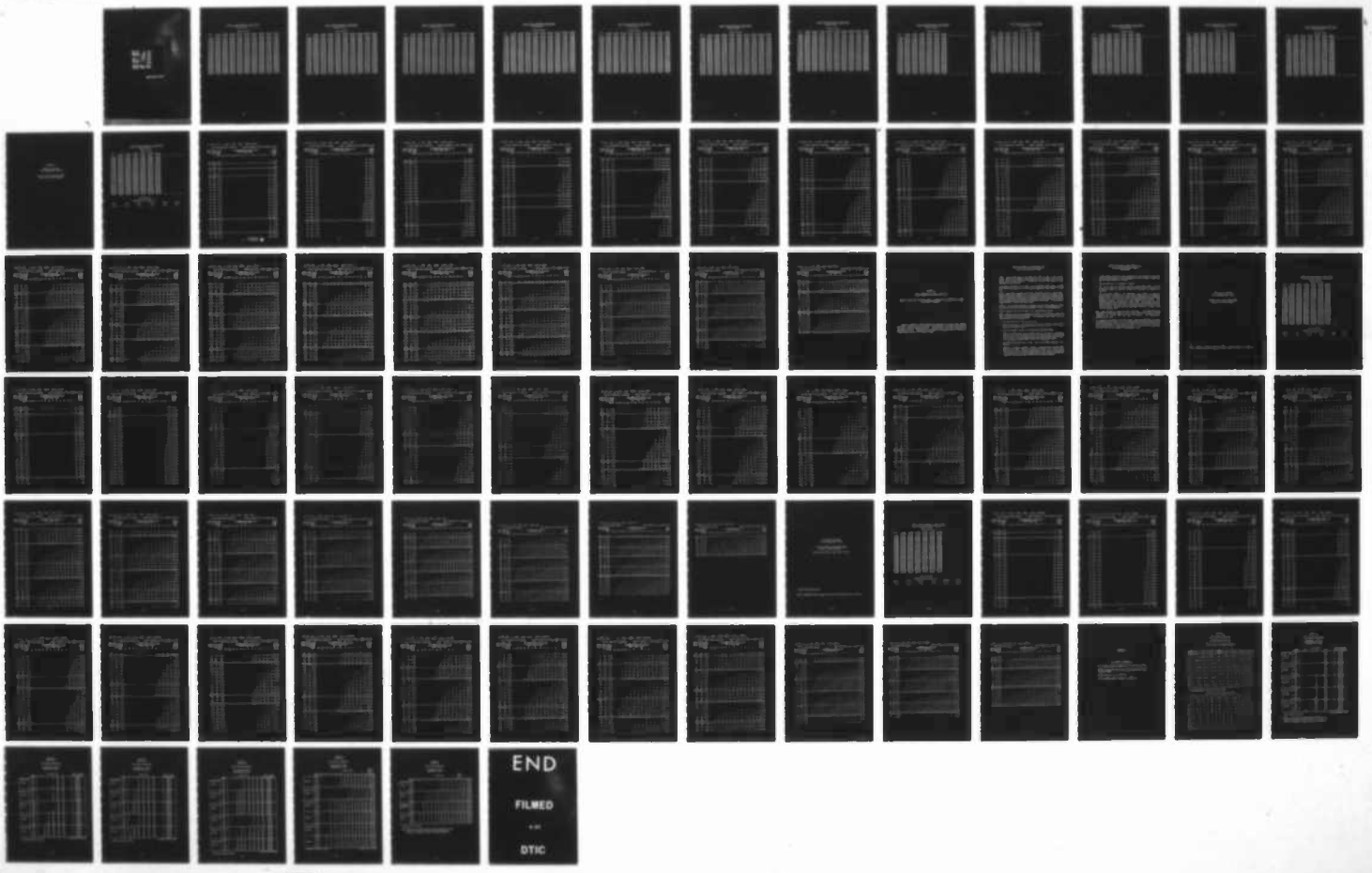
(HVAL01- HELIUM)

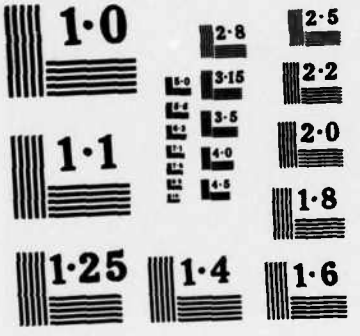
TISSUE HALF-TIMES

TH	5 MIN 1.00 SDR	10 MIN 1.00 SDR	20 MIN 1.00 SDR	40 MIN 1.00 SDR	80 MIN 1.00 SDR	120 MIN 1.00 SDR	160 MIN 1.00 SDR	200 MIN 1.00 SDR	240 MIN 1.00 SDR
FSW	130.000	110.000	83.000	66.000	54.000	48.000	44.500	44.000	43.500
FSW	140.000	120.000	93.000	76.000	64.000	58.000	54.500	54.000	53.500
FSW	150.000	130.000	103.000	86.000	74.000	68.000	64.500	64.000	63.500
FSW	160.000	140.000	113.000	96.000	84.000	78.000	74.500	74.000	73.500
FSW	170.000	150.000	123.000	106.000	94.000	88.000	84.500	84.000	83.500
FSW	180.000	160.000	133.000	116.000	104.000	98.000	94.500	94.000	93.500
FSW	190.000	170.000	143.000	126.000	114.000	108.000	104.500	104.000	103.500
FSW	200.000	180.000	153.000	136.000	124.000	118.000	114.500	114.000	113.500
FSW	210.000	190.000	163.000	146.000	134.000	128.000	124.500	124.000	123.500
FSW	220.000	200.000	173.000	156.000	144.000	138.000	134.500	134.000	133.500
FSW	230.000	210.000	183.000	166.000	154.000	148.000	144.500	144.000	143.500
FSW	240.000	220.000	193.000	176.000	164.000	158.000	154.500	154.000	153.500
FSW	250.000	230.000	203.000	186.000	174.000	168.000	164.500	164.000	163.500
FSW	260.000	240.000	213.000	196.000	184.000	178.000	174.500	174.000	173.500
FSW	270.000	250.000	223.000	206.000	194.000	188.000	184.500	184.000	183.500
FSW	280.000	260.000	233.000	216.000	204.000	198.000	194.500	194.000	193.500
FSW	290.000	270.000	243.000	226.000	214.000	208.000	204.500	204.000	203.500
FSW	300.000	280.000	253.000	236.000	224.000	218.000	214.500	214.000	213.500
FSW	310.000	290.000	263.000	246.000	234.000	228.000	224.500	224.000	223.500
FSW	320.000	300.000	273.000	256.000	244.000	238.000	234.500	234.000	233.500
FSW	330.000	310.000	283.000	266.000	254.000	248.000	244.500	244.000	243.500
FSW	340.000	320.000	293.000	276.000	264.000	258.000	254.500	254.000	253.500
FSW	350.000	330.000	303.000	286.000	274.000	268.000	264.500	264.000	263.500
FSW	360.000	340.000	313.000	296.000	284.000	278.000	274.500	274.000	273.500
FSW	370.000	350.000	323.000	306.000	294.000	288.000	284.500	284.000	283.500
FSW	380.000	360.000	333.000	316.000	304.000	298.000	294.500	294.000	293.500
FSW	390.000	370.000	343.000	326.000	314.000	308.000	304.500	304.000	303.500
FSW	400.000	380.000	353.000	336.000	324.000	318.000	314.500	314.000	313.500
FSW	410.000	390.000	363.000	346.000	334.000	328.000	324.500	324.000	323.500
FSW	420.000	400.000	373.000	356.000	344.000	338.000	334.500	334.000	333.500

AD-A158 142 DEVELOPMENT OF A DECOMPRESSION ALGORITHM FOR CONSTANT 07 ATA OXYGEN PARTI..(U) NAVY EXPERIMENTAL DIVING UNIT PANAMA CITY FL E D THALMANN APR 85 NEDU-1-85 2/2

UNCLASSIFIED F/G 6/19 NL





NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

<HVAL02- HELIUM >

TISSUE HALF-TIMES

DEPTH	5 MIN 1.00 SDR	10 MIN 1.00 SDR	20 MIN 1.00 SDR	40 MIN 1.00 SDR	80 MIN 1.00 SDR	120 MIN 1.00 SDR	160 MIN 1.00 SDR	200 MIN 1.00 SDR	240 MIN 1.00 SDR
10 FSW	130.000	110.000	88.000	70.000	56.000	50.000	45.500	44.000	43.500
20 FSW	140.000	120.000	98.000	80.000	66.000	60.000	55.500	54.000	53.500
30 FSW	150.000	130.000	108.000	90.000	76.000	70.000	65.500	64.000	63.500
40 FSW	160.000	140.000	118.000	100.000	86.000	80.000	75.500	74.000	73.500
50 FSW	170.000	150.000	128.000	110.000	96.000	90.000	85.500	84.000	83.500
60 FSW	180.000	160.000	138.000	120.000	106.000	100.000	95.500	94.000	93.500
70 FSW	190.000	170.000	148.000	130.000	116.000	110.000	105.500	104.000	103.500
80 FSW	200.000	180.000	158.000	140.000	126.000	120.000	115.500	114.000	113.500
90 FSW	210.000	190.000	168.000	150.000	136.000	130.000	125.500	124.000	123.500
100 FSW	220.000	200.000	178.000	160.000	146.000	140.000	135.500	134.000	133.500
110 FSW	230.000	210.000	188.000	170.000	156.000	150.000	145.500	144.000	143.500
120 FSW	240.000	220.000	198.000	180.000	166.000	160.000	155.500	154.000	153.500
130 FSW	250.000	230.000	208.000	190.000	176.000	170.000	165.500	164.000	163.500
140 FSW	260.000	240.000	218.000	200.000	186.000	180.000	175.500	174.000	173.500
150 FSW	270.000	250.000	228.000	210.000	196.000	190.000	185.500	184.000	183.500
160 FSW	280.000	260.000	238.000	220.000	206.000	200.000	195.500	194.000	193.500
170 FSW	290.000	270.000	248.000	230.000	216.000	210.000	205.500	204.000	203.500
180 FSW	300.000	280.000	258.000	240.000	226.000	220.000	215.500	214.000	213.500
190 FSW	310.000	290.000	268.000	250.000	236.000	230.000	225.500	224.000	223.500
200 FSW	320.000	300.000	278.000	260.000	246.000	240.000	235.500	234.000	233.500
210 FSW	330.000	310.000	288.000	270.000	256.000	250.000	245.500	244.000	243.500
220 FSW	340.000	320.000	298.000	280.000	266.000	260.000	255.500	254.000	253.500
230 FSW	350.000	330.000	308.000	290.000	276.000	270.000	265.500	264.000	263.500
240 FSW	360.000	340.000	318.000	300.000	286.000	280.000	275.500	274.000	273.500
250 FSW	370.000	350.000	328.000	310.000	296.000	290.000	285.500	284.000	283.500
260 FSW	380.000	360.000	338.000	320.000	306.000	300.000	295.500	294.000	293.500
270 FSW	390.000	370.000	348.000	330.000	316.000	310.000	305.500	304.000	303.500
280 FSW	400.000	380.000	358.000	340.000	326.000	320.000	315.500	314.000	313.500
290 FSW	410.000	390.000	368.000	350.000	336.000	330.000	325.500	324.000	323.500
300 FSW	420.000	400.000	378.000	360.000	346.000	340.000	335.500	334.000	333.500

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

<HVAL03- HELIUM >

TISSUE HALF-TIMES

DEPTH	5 MIN 1.00 SDR	10 MIN 1.00 SDR	20 MIN 1.00 SDR	40 MIN 1.00 SDR	80 MIN 1.00 SDR	120 MIN 1.00 SDR	160 MIN 1.00 SDR	200 MIN 1.00 SDR	240 MIN 1.00 SDR
10 FSW	130.000	107.000	83.000	68.000	56.000	50.000	45.500	44.000	43.500
20 FSW	140.000	117.000	93.000	78.000	66.000	60.000	55.500	54.000	53.500
30 FSW	150.000	127.000	103.000	88.000	76.000	70.000	65.500	64.000	63.500
40 FSW	160.000	137.000	113.000	98.000	86.000	80.000	75.500	74.000	73.500
50 FSW	170.000	147.000	123.000	108.000	96.000	90.000	85.500	84.000	83.500
60 FSW	180.000	157.000	133.000	118.000	106.000	100.000	95.500	94.000	93.500
70 FSW	190.000	167.000	143.000	128.000	116.000	110.000	105.500	104.000	103.500
80 FSW	200.000	177.000	153.000	138.000	126.000	120.000	115.500	114.000	113.500
90 FSW	210.000	187.000	163.000	148.000	136.000	130.000	125.500	124.000	123.500
100 FSW	220.000	197.000	173.000	158.000	146.000	140.000	135.500	134.000	133.500
110 FSW	230.000	207.000	183.000	168.000	156.000	150.000	145.500	144.000	143.500
120 FSW	240.000	217.000	193.000	178.000	166.000	160.000	155.500	154.000	153.500
130 FSW	250.000	227.000	203.000	188.000	176.000	170.000	165.500	164.000	163.500
140 FSW	260.000	237.000	213.000	198.000	186.000	180.000	175.500	174.000	173.500
150 FSW	270.000	247.000	223.000	208.000	196.000	190.000	185.500	184.000	183.500
160 FSW	280.000	257.000	233.000	218.000	206.000	200.000	195.500	194.000	193.500
170 FSW	290.000	267.000	243.000	228.000	216.000	210.000	205.500	204.000	203.500
180 FSW	300.000	277.000	253.000	238.000	226.000	220.000	215.500	214.000	213.500
190 FSW	310.000	287.000	263.000	248.000	236.000	230.000	225.500	224.000	223.500
200 FSW	320.000	297.000	273.000	258.000	246.000	240.000	235.500	234.000	233.500
210 FSW	330.000	307.000	283.000	268.000	256.000	250.000	245.500	244.000	243.500
220 FSW	340.000	317.000	293.000	278.000	266.000	260.000	255.500	254.000	253.500
230 FSW	350.000	327.000	303.000	288.000	276.000	270.000	265.500	264.000	263.500
240 FSW	360.000	337.000	313.000	298.000	286.000	280.000	275.500	274.000	273.500
250 FSW	370.000	347.000	323.000	308.000	296.000	290.000	285.500	284.000	283.500
260 FSW	380.000	357.000	333.000	318.000	306.000	300.000	295.500	294.000	293.500
270 FSW	390.000	367.000	343.000	328.000	316.000	310.000	305.500	304.000	303.500
280 FSW	400.000	377.000	353.000	338.000	326.000	320.000	315.500	314.000	313.500
290 FSW	410.000	387.000	363.000	348.000	336.000	330.000	325.500	324.000	323.500
300 FSW	420.000	397.000	373.000	358.000	346.000	340.000	335.500	334.000	333.500

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(HVAL04- HELIUM)

TISSUE HALF-TIMES

DEPTH	5 MIN 1.00 SDR	10 MIN 1.00 SDR	20 MIN 1.00 SDR	40 MIN 1.00 SDR	80 MIN 1.00 SDR	120 MIN 1.00 SDR	160 MIN 1.00 SDR	200 MIN 1.00 SDR	240 MIN 1.00 SDR
10 FSW	128.000	103.000	82.000	68.000	56.000	50.000	45.500	44.000	43.500
20 FSW	138.000	113.000	92.000	78.000	66.000	60.000	55.500	54.000	53.500
30 FSW	148.000	123.000	102.000	88.000	76.000	70.000	65.500	64.000	63.500
40 FSW	158.000	133.000	112.000	98.000	86.000	80.000	75.500	74.000	73.500
50 FSW	168.000	143.000	122.000	108.000	96.000	90.000	85.500	84.000	83.500
60 FSW	178.000	153.000	132.000	118.000	106.000	100.000	95.500	94.000	93.500
70 FSW	188.000	163.000	142.000	128.000	116.000	110.000	105.500	104.000	103.500
80 FSW	198.000	173.000	152.000	138.000	126.000	120.000	115.500	114.000	113.500
90 FSW	208.000	183.000	162.000	148.000	136.000	130.000	125.500	124.000	123.500
100 FSW	218.000	193.000	172.000	158.000	146.000	140.000	135.500	134.000	133.500
110 FSW	228.000	203.000	182.000	168.000	156.000	150.000	145.500	144.000	143.500
120 FSW	238.000	213.000	192.000	178.000	166.000	160.000	155.500	154.000	153.500
130 FSW	248.000	223.000	202.000	188.000	176.000	170.000	165.500	164.000	163.500
140 FSW	258.000	233.000	212.000	198.000	186.000	180.000	175.500	174.000	173.500
150 FSW	268.000	243.000	222.000	208.000	196.000	190.000	185.500	184.000	183.500
160 FSW	278.000	253.000	232.000	218.000	206.000	200.000	195.500	194.000	193.500
170 FSW	288.000	263.000	242.000	228.000	216.000	210.000	205.500	204.000	203.500
180 FSW	298.000	273.000	252.000	238.000	226.000	220.000	215.500	214.000	213.500
190 FSW	308.000	283.000	262.000	248.000	236.000	230.000	225.500	224.000	223.500
200 FSW	318.000	293.000	272.000	258.000	246.000	240.000	235.500	234.000	233.500
210 FSW	328.000	303.000	282.000	268.000	256.000	250.000	245.500	244.000	243.500
220 FSW	338.000	313.000	292.000	278.000	266.000	260.000	255.500	254.000	253.500
230 FSW	348.000	323.000	302.000	288.000	276.000	270.000	265.500	264.000	263.500
240 FSW	358.000	333.000	312.000	298.000	286.000	280.000	275.500	274.000	273.500
250 FSW	368.000	343.000	322.000	308.000	296.000	290.000	285.500	284.000	283.500
260 FSW	378.000	353.000	332.000	318.000	306.000	300.000	295.500	294.000	293.500
270 FSW	388.000	363.000	342.000	328.000	316.000	310.000	305.500	304.000	303.500
280 FSW	398.000	373.000	352.000	338.000	326.000	320.000	315.500	314.000	313.500
290 FSW	408.000	383.000	362.000	348.000	336.000	330.000	325.500	324.000	323.500
300 FSW	418.000	393.000	372.000	358.000	346.000	340.000	335.500	334.000	333.500

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(HVAL 05- HELIUM)

TISSUE HALF-TIMES

DEPTH	5 MIN 1.00 SDR	10 MIN 1.00 SDR	20 MIN 1.00 SDR	40 MIN 1.00 SDR	80 MIN 1.00 SDR	120 MIN 1.00 SDR	160 MIN 1.00 SDR	200 MIN 1.00 SDR	240 MIN 1.00 SDR
10 FSW	125.000	100.000	82.000	68.000	56.000	50.000	45.500	44.000	43.500
20 FSW	135.000	110.000	92.000	78.000	66.000	60.000	55.500	54.000	53.500
30 FSW	145.000	120.000	102.000	88.000	76.000	70.000	65.500	64.000	63.500
40 FSW	155.000	130.000	112.000	98.000	86.000	80.000	75.500	74.000	73.500
50 FSW	165.000	140.000	122.000	108.000	96.000	90.000	85.500	84.000	83.500
60 FSW	175.000	150.000	132.000	118.000	106.000	100.000	95.500	94.000	93.500
70 FSW	185.000	160.000	142.000	128.000	116.000	110.000	105.500	104.000	103.500
80 FSW	195.000	170.000	152.000	138.000	126.000	120.000	115.500	114.000	113.500
90 FSW	205.000	180.000	162.000	148.000	136.000	130.000	125.500	124.000	123.500
100 FSW	215.000	190.000	172.000	158.000	146.000	140.000	135.500	134.000	133.500
110 FSW	225.000	200.000	182.000	168.000	156.000	150.000	145.500	144.000	143.500
120 FSW	235.000	210.000	192.000	178.000	166.000	160.000	155.500	154.000	153.500
130 FSW	245.000	220.000	202.000	188.000	176.000	170.000	165.500	164.000	163.500
140 FSW	255.000	230.000	212.000	198.000	186.000	180.000	175.500	174.000	173.500
150 FSW	265.000	240.000	222.000	208.000	196.000	190.000	185.500	184.000	183.500
160 FSW	275.000	250.000	232.000	218.000	206.000	200.000	195.500	194.000	193.500
170 FSW	285.000	260.000	242.000	228.000	216.000	210.000	205.500	204.000	203.500
180 FSW	295.000	270.000	252.000	238.000	226.000	220.000	215.500	214.000	213.500
190 FSW	305.000	280.000	262.000	248.000	236.000	230.000	225.500	224.000	223.500
200 FSW	315.000	290.000	272.000	258.000	246.000	240.000	235.500	234.000	233.500
210 FSW	325.000	300.000	282.000	268.000	256.000	250.000	245.500	244.000	243.500
220 FSW	335.000	310.000	292.000	278.000	266.000	260.000	255.500	254.000	253.500
230 FSW	345.000	320.000	302.000	288.000	276.000	270.000	265.500	264.000	263.500
240 FSW	355.000	330.000	312.000	298.000	286.000	280.000	275.500	274.000	273.500
250 FSW	365.000	340.000	322.000	308.000	296.000	290.000	285.500	284.000	283.500
260 FSW	375.000	350.000	332.000	318.000	306.000	300.000	295.500	294.000	293.500
270 FSW	385.000	360.000	342.000	328.000	316.000	310.000	305.500	304.000	303.500
280 FSW	395.000	370.000	352.000	338.000	326.000	320.000	315.500	314.000	313.500
290 FSW	405.000	380.000	362.000	348.000	336.000	330.000	325.500	324.000	323.500
300 FSW	415.000	390.000	372.000	358.000	346.000	340.000	335.500	334.000	333.500

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(HVAL06- HELIUM)

TISSUE HALF-TIMES

DEPTH	5 MIN 1.00 SDR	10 MIN 1.00 SDR	20 MIN 1.00 SDR	40 MIN 1.00 SDR	80 MIN 1.00 SDR	120 MIN 1.00 SDR	160 MIN 1.00 SDR	200 MIN 1.00 SDR	240 MIN 1.00 SDR
10 FSW	120.000	98.000	80.000	68.000	56.000	50.000	45.500	44.000	43.500
20 FSW	130.000	108.000	90.000	78.000	66.000	60.000	55.500	54.000	53.500
30 FSW	140.000	118.000	100.000	88.000	76.000	70.000	65.500	64.000	63.500
40 FSW	150.000	128.000	110.000	98.000	86.000	80.000	75.500	74.000	73.500
50 FSW	160.000	138.000	120.000	108.000	96.000	90.000	85.500	84.000	83.500
60 FSW	170.000	148.000	130.000	118.000	106.000	100.000	95.500	94.000	93.500
70 FSW	180.000	158.000	140.000	128.000	116.000	110.000	105.500	104.000	103.500
80 FSW	190.000	168.000	150.000	138.000	126.000	120.000	115.500	114.000	113.500
90 FSW	200.000	178.000	160.000	148.000	136.000	130.000	125.500	124.000	123.500
100 FSW	210.000	188.000	170.000	158.000	146.000	140.000	135.500	134.000	133.500
110 FSW	220.000	198.000	180.000	168.000	156.000	150.000	145.500	144.000	143.500
120 FSW	230.000	208.000	190.000	178.000	166.000	160.000	155.500	154.000	153.500
130 FSW	240.000	218.000	200.000	188.000	176.000	170.000	165.500	164.000	163.500
140 FSW	250.000	228.000	210.000	198.000	186.000	180.000	175.500	174.000	173.500
150 FSW	260.000	238.000	220.000	208.000	196.000	190.000	185.500	184.000	183.500
160 FSW	270.000	248.000	230.000	218.000	206.000	200.000	195.500	194.000	193.500
170 FSW	280.000	258.000	240.000	228.000	216.000	210.000	205.500	204.000	203.500
180 FSW	290.000	268.000	250.000	238.000	226.000	220.000	215.500	214.000	213.500
190 FSW	300.000	278.000	260.000	248.000	236.000	230.000	225.500	224.000	223.500
200 FSW	310.000	288.000	270.000	258.000	246.000	240.000	235.500	234.000	233.500
210 FSW	320.000	298.000	280.000	268.000	256.000	250.000	245.500	244.000	243.500
220 FSW	330.000	308.000	290.000	278.000	266.000	260.000	255.500	254.000	253.500
230 FSW	340.000	318.000	300.000	288.000	276.000	270.000	265.500	264.000	263.500
240 FSW	350.000	328.000	310.000	298.000	286.000	280.000	275.500	274.000	273.500
250 FSW	360.000	338.000	320.000	308.000	296.000	290.000	285.500	284.000	283.500
260 FSW	370.000	348.000	330.000	318.000	306.000	300.000	295.500	294.000	293.500
270 FSW	380.000	358.000	340.000	328.000	316.000	310.000	305.500	304.000	303.500
280 FSW	390.000	368.000	350.000	338.000	326.000	320.000	315.500	314.000	313.500
290 FSW	400.000	378.000	360.000	348.000	336.000	330.000	325.500	324.000	323.500
300 FSW	410.000	388.000	370.000	358.000	346.000	340.000	335.500	334.000	333.500

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(HVAL07- HELIUM)

TISSUE HALF-TIMES

DEPTH	5 MIN 1.00 SDR	10 MIN 1.00 SDR	20 MIN 1.00 SDR	40 MIN 1.00 SDR	80 MIN 1.00 SDR	120 MIN 1.00 SDR	160 MIN 1.00 SDR	200 MIN 1.00 SDR	240 MIN 1.00 SDR
10 FSW	120.000	98.000	80.000	68.000	56.000	50.000	49.000	48.000	47.000
20 FSW	132.000	110.000	92.000	80.000	68.000	62.000	61.000	60.000	59.000
30 FSW	144.000	122.000	104.000	92.000	80.000	74.000	73.000	72.000	71.000
40 FSW	156.000	134.000	116.000	104.000	92.000	86.000	85.000	84.000	83.000
50 FSW	168.000	146.000	128.000	116.000	104.000	98.000	97.000	96.000	95.000
60 FSW	180.000	158.000	140.000	128.000	116.000	110.000	109.000	108.000	107.000
70 FSW	192.000	170.000	152.000	140.000	128.000	122.000	121.000	120.000	119.000
80 FSW	204.000	182.000	164.000	152.000	140.000	134.000	133.000	132.000	131.000
90 FSW	216.000	194.000	176.000	164.000	152.000	146.000	145.000	144.000	143.000
100 FSW	228.000	206.000	188.000	176.000	164.000	158.000	157.000	156.000	155.000
110 FSW	240.000	218.000	200.000	188.000	176.000	170.000	169.000	168.000	167.000
120 FSW	252.000	230.000	212.000	200.000	188.000	182.000	181.000	180.000	179.000
130 FSW	264.000	242.000	224.000	212.000	200.000	194.000	193.000	192.000	191.000
140 FSW	276.000	254.000	236.000	224.000	212.000	206.000	205.000	204.000	203.000
150 FSW	288.000	266.000	248.000	236.000	224.000	218.000	217.000	216.000	215.000
160 FSW	300.000	278.000	260.000	248.000	236.000	230.000	229.000	228.000	227.000
170 FSW	312.000	290.000	272.000	260.000	248.000	242.000	241.000	240.000	239.000
180 FSW	324.000	302.000	284.000	272.000	260.000	254.000	253.000	252.000	251.000
190 FSW	336.000	314.000	296.000	284.000	272.000	266.000	265.000	264.000	263.000
200 FSW	348.000	326.000	308.000	296.000	284.000	278.000	277.000	276.000	275.000
210 FSW	360.000	338.000	320.000	308.000	296.000	290.000	289.000	288.000	287.000
220 FSW	372.000	350.000	332.000	320.000	308.000	302.000	301.000	300.000	299.000
230 FSW	384.000	362.000	344.000	332.000	320.000	314.000	313.000	312.000	311.000
240 FSW	396.000	374.000	356.000	344.000	332.000	326.000	325.000	324.000	323.000
250 FSW	408.000	386.000	368.000	356.000	344.000	338.000	337.000	336.000	335.000
260 FSW	420.000	398.000	380.000	368.000	356.000	350.000	349.000	348.000	347.000
270 FSW	432.000	410.000	392.000	380.000	368.000	362.000	361.000	360.000	359.000
280 FSW	444.000	422.000	404.000	392.000	380.000	374.000	373.000	372.000	371.000
290 FSW	456.000	434.000	416.000	404.000	392.000	386.000	385.000	384.000	383.000
300 FSW	468.000	446.000	428.000	416.000	404.000	398.000	397.000	396.000	395.000

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(HVAL09- HELIUM)

TISSUE HALF-TIMES

DEPTH	5 MIN 1.00 SDR	10 MIN 1.00 SDR	20 MIN 1.00 SDR	40 MIN 1.00 SDR	80 MIN 1.00 SDR	120 MIN 1.00 SDR	160 MIN 1.00 SDR	200 MIN 1.00 SDR	240 MIN 1.00 SDR
10 FSW	120.000	98.000	80.000	68.000	56.000	48.000	47.500	47.000	46.800
20 FSW	132.000	110.000	92.000	80.000	68.000	60.000	59.500	59.000	58.800
30 FSW	144.000	122.000	104.000	92.000	80.000	72.000	71.500	71.000	70.800
40 FSW	156.000	134.000	116.000	104.000	92.000	84.000	83.500	83.000	82.800
50 FSW	168.000	146.000	128.000	116.000	104.000	96.000	95.500	95.000	94.800
60 FSW	180.000	158.000	140.000	128.000	116.000	108.000	107.500	107.000	106.800
70 FSW	192.000	170.000	152.000	140.000	128.000	120.000	119.500	119.000	118.800
80 FSW	204.000	182.000	164.000	152.000	140.000	132.000	131.500	131.000	130.800
90 FSW	216.000	194.000	176.000	164.000	152.000	144.000	143.500	143.000	142.800
100 FSW	228.000	206.000	188.000	176.000	164.000	156.000	155.500	155.000	154.800
110 FSW	240.000	218.000	200.000	188.000	176.000	168.000	167.500	167.000	166.800
120 FSW	252.000	230.000	212.000	200.000	188.000	180.000	179.500	179.000	178.800
130 FSW	264.000	242.000	224.000	212.000	200.000	192.000	191.500	191.000	190.800
140 FSW	276.000	254.000	236.000	224.000	212.000	204.000	203.500	203.000	202.800
150 FSW	288.000	266.000	248.000	236.000	224.000	216.000	215.500	215.000	214.800
160 FSW	300.000	278.000	260.000	248.000	236.000	228.000	227.500	227.000	226.800
170 FSW	312.000	290.000	272.000	260.000	248.000	240.000	239.500	239.000	238.800
180 FSW	324.000	302.000	284.000	272.000	260.000	252.000	251.500	251.000	250.800
190 FSW	336.000	314.000	296.000	284.000	272.000	264.000	263.500	263.000	262.800
200 FSW	348.000	326.000	308.000	296.000	284.000	276.000	275.500	275.000	274.800
210 FSW	360.000	338.000	320.000	308.000	296.000	288.000	287.500	287.000	286.800
220 FSW	372.000	350.000	332.000	320.000	308.000	300.000	299.500	299.000	298.800
230 FSW	384.000	362.000	344.000	332.000	320.000	312.000	311.500	311.000	310.800
240 FSW	396.000	374.000	356.000	344.000	332.000	324.000	323.500	323.000	322.800
250 FSW	408.000	386.000	368.000	356.000	344.000	336.000	335.500	335.000	334.800
260 FSW	420.000	398.000	380.000	368.000	356.000	348.000	347.500	347.000	346.800
270 FSW	432.000	410.000	392.000	380.000	368.000	360.000	359.500	359.000	358.800
280 FSW	444.000	422.000	404.000	392.000	380.000	372.000	371.500	371.000	370.800
290 FSW	456.000	434.000	416.000	404.000	392.000	384.000	383.500	383.000	382.800
300 FSW	468.000	446.000	428.000	416.000	404.000	396.000	395.500	395.000	394.800

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(HVAL11- HELIUM)

TISSUE HALF-TIMES

DEPTH	5 MIN 1.00 SDR	10 MIN .91 SDR	20 MIN .83 SDR	40 MIN .83 SDR	80 MIN .83 SDR	120 MIN .83 SDR
10 FSW	120.000	98.000	82.000	68.000	56.000	50.000
20 FSW	132.000	110.000	94.000	80.000	68.000	62.000
30 FSW	144.000	122.000	106.000	92.000	80.000	74.000
40 FSW	156.000	134.000	118.000	104.000	92.000	86.000
50 FSW	168.000	146.000	130.000	116.000	104.000	98.000
60 FSW	180.000	158.000	142.000	128.000	116.000	110.000
70 FSW	192.000	170.000	154.000	140.000	128.000	122.000
80 FSW	204.000	182.000	166.000	152.000	140.000	134.000
90 FSW	216.000	194.000	178.000	164.000	152.000	146.000
100 FSW	228.000	206.000	190.000	176.000	164.000	158.000
110 FSW	240.000	218.000	202.000	188.000	176.000	170.000
120 FSW	252.000	230.000	214.000	200.000	188.000	182.000
130 FSW	264.000	242.000	226.000	212.000	200.000	194.000
140 FSW	276.000	254.000	238.000	224.000	212.000	206.000
150 FSW	288.000	266.000	250.000	236.000	224.000	218.000
160 FSW	300.000	278.000	262.000	248.000	236.000	230.000
170 FSW	312.000	290.000	274.000	260.000	248.000	242.000
180 FSW	324.000	302.000	286.000	272.000	260.000	254.000
190 FSW	336.000	314.000	298.000	284.000	272.000	266.000
200 FSW	348.000	326.000	310.000	296.000	284.000	278.000
210 FSW	360.000	338.000	322.000	308.000	296.000	290.000
220 FSW	372.000	350.000	334.000	320.000	308.000	302.000
230 FSW	384.000	362.000	346.000	332.000	320.000	314.000
240 FSW	396.000	374.000	358.000	344.000	332.000	326.000
250 FSW	408.000	386.000	370.000	356.000	344.000	338.000
260 FSW	420.000	398.000	382.000	368.000	356.000	350.000
270 FSW	432.000	410.000	394.000	380.000	368.000	362.000
280 FSW	444.000	422.000	406.000	392.000	380.000	374.000
290 FSW	456.000	434.000	418.000	404.000	392.000	386.000
300 FSW	468.000	446.000	430.000	416.000	404.000	398.000

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(HVAL12- HELIUM)

TISSUE HALF-TIMES

DEPTH	5 MIN .63 SDR	10 MIN .66 SDR	20 MIN .71 SDR	40 MIN .83 SDR	80 MIN .83 SDR	120 MIN .83 SDR			
10 FSW	120.000	98.000	82.000	68.000	56.000	50.000			
20 FSW	132.000	110.000	94.000	80.000	68.000	62.000			
30 FSW	144.000	122.000	106.000	92.000	80.000	74.000			
40 FSW	156.000	134.000	118.000	104.000	92.000	86.000			
50 FSW	168.000	146.000	130.000	116.000	104.000	98.000			
60 FSW	180.000	158.000	142.000	128.000	116.000	110.000			
70 FSW	192.000	170.000	154.000	140.000	128.000	122.000			
80 FSW	204.000	182.000	166.000	152.000	140.000	134.000			
90 FSW	216.000	194.000	178.000	164.000	152.000	146.000			
100 FSW	228.000	206.000	190.000	176.000	164.000	158.000			
110 FSW	240.000	218.000	202.000	188.000	176.000	170.000			
120 FSW	252.000	230.000	214.000	200.000	188.000	182.000			
130 FSW	264.000	242.000	226.000	212.000	200.000	194.000			
140 FSW	276.000	254.000	238.000	224.000	212.000	206.000			
150 FSW	288.000	266.000	250.000	236.000	224.000	218.000			
160 FSW	300.000	278.000	262.000	248.000	236.000	230.000			
170 FSW	312.000	290.000	274.000	260.000	248.000	242.000			
180 FSW	324.000	302.000	286.000	272.000	260.000	254.000			
190 FSW	336.000	314.000	298.000	284.000	272.000	266.000			
200 FSW	348.000	326.000	310.000	296.000	284.000	278.000			
210 FSW	360.000	338.000	322.000	308.000	296.000	290.000			
220 FSW	372.000	350.000	334.000	320.000	308.000	302.000			
230 FSW	384.000	362.000	346.000	332.000	320.000	314.000			
240 FSW	396.000	374.000	358.000	344.000	332.000	326.000			
250 FSW	408.000	386.000	370.000	356.000	344.000	338.000			
260 FSW	420.000	398.000	382.000	368.000	356.000	350.000			
270 FSW	432.000	410.000	394.000	380.000	368.000	362.000			
280 FSW	444.000	422.000	406.000	392.000	380.000	374.000			
290 FSW	456.000	434.000	418.000	404.000	392.000	386.000			
300 FSW	468.000	446.000	430.000	416.000	404.000	398.000			

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(HVAL13- HELIUM)

TISSUE HALF-TIMES

DEPTH	5 MIN 1.00 SDR	10 MIN .83 SDR	20 MIN .71 SDR	40 MIN .83 SDR	80 MIN .83 SDR	120 MIN .83 SDR			
10 FSW	120.000	98.000	82.000	68.000	56.000	50.000			
20 FSW	132.000	110.000	94.000	80.000	68.000	62.000			
30 FSW	144.000	122.000	106.000	92.000	80.000	74.000			
40 FSW	156.000	134.000	118.000	104.000	92.000	86.000			
50 FSW	168.000	146.000	130.000	116.000	104.000	98.000			
60 FSW	180.000	158.000	142.000	128.000	116.000	110.000			
70 FSW	192.000	170.000	154.000	140.000	128.000	122.000			
80 FSW	204.000	182.000	166.000	152.000	140.000	134.000			
90 FSW	216.000	194.000	178.000	164.000	152.000	146.000			
100 FSW	228.000	206.000	190.000	176.000	164.000	158.000			
110 FSW	240.000	218.000	202.000	188.000	176.000	170.000			
120 FSW	252.000	230.000	214.000	200.000	188.000	182.000			
130 FSW	264.000	242.000	226.000	212.000	200.000	194.000			
140 FSW	276.000	254.000	238.000	224.000	212.000	206.000			
150 FSW	288.000	266.000	250.000	236.000	224.000	218.000			
160 FSW	300.000	278.000	262.000	248.000	236.000	230.000			
170 FSW	312.000	290.000	274.000	260.000	248.000	242.000			
180 FSW	324.000	302.000	286.000	272.000	260.000	254.000			
190 FSW	336.000	314.000	298.000	284.000	272.000	266.000			
200 FSW	348.000	326.000	310.000	296.000	284.000	278.000			
210 FSW	360.000	338.000	322.000	308.000	296.000	290.000			
220 FSW	372.000	350.000	334.000	320.000	308.000	302.000			
230 FSW	384.000	362.000	346.000	332.000	320.000	314.000			
240 FSW	396.000	374.000	358.000	344.000	332.000	326.000			
250 FSW	408.000	386.000	370.000	356.000	344.000	338.000			
260 FSW	420.000	398.000	382.000	368.000	356.000	350.000			
270 FSW	432.000	410.000	394.000	380.000	368.000	362.000			
280 FSW	444.000	422.000	406.000	392.000	380.000	374.000			
290 FSW	456.000	434.000	418.000	404.000	392.000	386.000			
300 FSW	468.000	446.000	430.000	416.000	404.000	398.000			

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(HVAL16- HELIUM)

TISSUE HALF-TIMES

EPTH	5 MIN 1.00 SDR	10 MIN .83 SDR	20 MIN .71 SDR	40 MIN .83 SDR	80 MIN .83 SDR	120 MIN .83 SDR			
0 FSW	115.000	96.000	77.000	65.000	55.000	48.000			
0 FSW	127.000	108.000	89.000	77.000	67.000	60.000			
0 FSW	139.000	120.000	101.000	89.000	79.000	72.000			
0 FSW	151.000	132.000	113.000	101.000	91.000	84.000			
0 FSW	163.000	144.000	125.000	113.000	103.000	96.000			
0 FSW	175.000	156.000	137.000	125.000	115.000	108.000			
0 FSW	187.000	168.000	149.000	137.000	127.000	120.000			
0 FSW	199.000	180.000	161.000	149.000	139.000	132.000			
0 FSW	211.000	192.000	173.000	161.000	151.000	144.000			
0 FSW	223.000	204.000	185.000	173.000	163.000	156.000			
0 FSW	235.000	216.000	197.000	185.000	175.000	168.000			
0 FSW	247.000	228.000	209.000	197.000	187.000	180.000			
0 FSW	259.000	240.000	221.000	209.000	199.000	192.000			
0 FSW	271.000	252.000	233.000	221.000	211.000	204.000			
0 FSW	283.000	264.000	245.000	233.000	223.000	216.000			
0 FSW	295.000	276.000	257.000	245.000	235.000	228.000			
0 FSW	307.000	288.000	269.000	257.000	247.000	240.000			
0 FSW	319.000	300.000	281.000	269.000	259.000	252.000			
0 FSW	331.000	312.000	293.000	281.000	271.000	264.000			
0 FSW	343.000	324.000	305.000	293.000	283.000	276.000			
0 FSW	355.000	336.000	317.000	305.000	295.000	288.000			
0 FSW	367.000	348.000	329.000	317.000	307.000	300.000			
0 FSW	379.000	360.000	341.000	329.000	319.000	312.000			
0 FSW	391.000	372.000	353.000	341.000	331.000	324.000			
0 FSW	403.000	384.000	365.000	353.000	343.000	336.000			
0 FSW	415.000	396.000	377.000	365.000	355.000	348.000			
0 FSW	427.000	408.000	389.000	377.000	367.000	360.000			
0 FSW	439.000	420.000	401.000	389.000	379.000	372.000			
0 FSW	451.000	432.000	413.000	401.000	391.000	384.000			
0 FSW	463.000	444.000	425.000	413.000	403.000	396.000			

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(HVAL21- HELIUM)

TISSUE HALF-TIMES

DEPTH	5 MIN 1.00 SDR	10 MIN .83 SDR	20 MIN .71 SDR	40 MIN .83 SDR	80 MIN .83 SDR	120 MIN .83 SDR			
10 FSW	115.000	96.000	77.000	65.000	55.000	48.000			
20 FSW	126.000	107.000	88.000	76.000	66.000	59.000			
30 FSW	137.000	118.000	99.000	87.000	77.000	70.000			
40 FSW	148.000	129.000	110.000	98.000	88.000	81.000			
50 FSW	159.000	140.000	121.000	109.000	99.000	92.000			
60 FSW	170.000	151.000	132.000	120.000	110.000	103.000			
70 FSW	181.000	162.000	143.000	131.000	121.000	114.000			
80 FSW	192.000	173.000	154.000	142.000	132.000	125.000			
90 FSW	203.000	184.000	165.000	153.000	143.000	136.000			
100 FSW	214.000	195.000	176.000	164.000	154.000	147.000			
110 FSW	225.000	206.000	187.000	175.000	165.000	158.000			
120 FSW	236.000	217.000	198.000	186.000	176.000	169.000			
130 FSW	247.000	228.000	209.000	197.000	187.000	180.000			
140 FSW	258.000	239.000	220.000	208.000	198.000	191.000			
150 FSW	269.000	250.000	231.000	219.000	209.000	202.000			
160 FSW	280.000	261.000	242.000	230.000	220.000	213.000			
170 FSW	291.000	272.000	253.000	241.000	231.000	224.000			
180 FSW	302.000	283.000	264.000	252.000	242.000	235.000			
190 FSW	313.000	294.000	275.000	263.000	253.000	246.000			
200 FSW	324.000	305.000	286.000	274.000	264.000	257.000			
210 FSW	335.000	316.000	297.000	285.000	275.000	268.000			
220 FSW	346.000	327.000	308.000	296.000	286.000	279.000			
230 FSW	357.000	338.000	319.000	307.000	297.000	290.000			
240 FSW	368.000	349.000	330.000	318.000	308.000	301.000			
250 FSW	379.000	360.000	341.000	329.000	319.000	312.000			
260 FSW	390.000	371.000	352.000	340.000	330.000	323.000			
270 FSW	401.000	382.000	363.000	351.000	341.000	334.000			
280 FSW	412.000	393.000	374.000	362.000	352.000	345.000			
290 FSW	423.000	404.000	385.000	373.000	363.000	356.000			
300 FSW	434.000	415.000	396.000	384.000	374.000	367.000			

APPENDIX F

HVAL13 0.7 ATA PO_2 in He Decompression Tables

Depth in Feet of Sea Water (FSW)
Stops in 10 FSW Increments

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(HVAL13- HELIUM)

TISSUE HALF-TIMES

DEPTH	5 MIN 1.00 SDR	10 MIN .83 SDR	20 MIN .71 SDR	40 MIN .83 SDR	80 MIN .83 SDR	120 MIN .83 SDR
10 FSW	120.000	98.000	82.000	68.000	56.000	50.000
20 FSW	132.000	110.000	94.000	80.000	68.000	62.000
30 FSW	144.000	122.000	106.000	92.000	80.000	74.000
40 FSW	156.000	134.000	118.000	104.000	92.000	86.000
50 FSW	168.000	146.000	130.000	116.000	104.000	98.000
60 FSW	180.000	158.000	142.000	128.000	116.000	110.000
70 FSW	192.000	170.000	154.000	140.000	128.000	122.000
80 FSW	204.000	182.000	166.000	152.000	140.000	134.000
90 FSW	216.000	194.000	178.000	164.000	152.000	146.000
100 FSW	228.000	206.000	190.000	176.000	164.000	158.000
110 FSW	240.000	218.000	202.000	188.000	176.000	170.000
120 FSW	252.000	230.000	214.000	200.000	188.000	182.000
130 FSW	264.000	242.000	226.000	212.000	200.000	194.000
140 FSW	276.000	254.000	238.000	224.000	212.000	206.000
150 FSW	288.000	266.000	250.000	236.000	224.000	218.000
160 FSW	300.000	278.000	262.000	248.000	236.000	230.000
170 FSW	312.000	290.000	274.000	260.000	248.000	242.000
180 FSW	324.000	302.000	286.000	272.000	260.000	254.000
190 FSW	336.000	314.000	298.000	284.000	272.000	266.000
200 FSW	348.000	326.000	310.000	296.000	284.000	278.000
210 FSW	360.000	338.000	322.000	308.000	296.000	290.000
220 FSW	372.000	350.000	334.000	320.000	308.000	302.000
230 FSW	384.000	362.000	346.000	332.000	320.000	314.000
240 FSW	396.000	374.000	358.000	344.000	332.000	326.000
250 FSW	408.000	386.000	370.000	356.000	344.000	338.000
260 FSW	420.000	398.000	382.000	368.000	356.000	350.000
270 FSW	432.000	410.000	394.000	380.000	368.000	362.000
280 FSW	444.000	422.000	406.000	392.000	380.000	374.000
290 FSW	456.000	434.000	418.000	404.000	392.000	386.000
300 FSW	468.000	446.000	430.000	416.000	404.000	398.000

BLOOD PARAMETERS

(PRESSURE IN FSW; 33 FSW=1 ATA)

PACO2	PH2O	PVCO2	PVO2	AMBAO2	P80VP
1.50	0.00	2.30	2.00	0.00	0.000

10:49 AM TUE., 16 APR., 1985 TBLP7 HVAL13 (FEET)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
40	370	0:40													0	0:40
limit line																
40	380	0:40													0	0:40
40	390	0:40													0	0:40
50	242	0:50													0	0:50
50	250	0:40													4	4:50
limit line																
50	260	0:40													9	9:50
50	270	0:40													13	13:50
50	280	0:40													17	17:50
50	290	0:40													21	21:50
50	300	0:40													25	25:50
50	310	0:40													28	28:50
50	320	0:40													31	31:50
50	330	0:40													34	34:50
50	340	0:40													37	37:50
50	350	0:40													40	40:50
50	360	0:40													43	43:50
50	370	0:40													45	45:50
50	380	0:40													47	47:50
50	390	0:40													50	50:50
60	146	1:00													0	1:00
60	150	0:50													3	4:00
60	160	0:50													10	11:00
60	170	0:50													20	21:00
limit line																
60	180	0:50													29	30:00
60	190	0:50													38	39:00

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
60	200	0:50													47	48:00
60	210	0:50													55	56:00
60	220	0:50													62	63:00
60	230	0:50													69	70:00
60	240	0:50													76	77:00
60	250	0:50													82	83:00
60	260	0:50													88	89:00
60	270	0:50													94	95:00
60	280	0:50													99	100:00
60	290	0:50													104	105:00
60	300	0:50													109	110:00
60	310	0:50													113	114:00
60	320	0:50													118	119:00
60	330	0:50													122	123:00
60	340	0:40												2	123	126:00
60	350	0:40												6	123	130:00
60	360	0:40												9	123	133:00
60	370	0:40												12	124	137:00
60	380	0:40												15	124	140:00
60	390	0:40												18	123	142:00
70	96	1:10													0	1:10
70	100	1:00													2	3:10
70	110	1:00													10	11:10
70	120	1:00													22	23:10
70	130	1:00													33	34:10

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
70	140	1:00													45	46:10
limit line																
70	150	1:00													58	59:10
70	160	1:00													72	73:10
70	170	1:00													84	85:10
70	180	1:00													95	96:10
70	190	1:00													106	107:10
70	200	0:50												6	111	118:10
70	210	0:50												11	116	128:10
70	220	0:50												16	120	137:10
70	230	0:50												21	124	146:10
70	240	0:50												30	123	154:10
70	250	0:50												37	124	162:10
70	260	0:50												45	123	169:10
70	270	0:50												52	123	176:10
80	67	1:20													0	1:20
80	70	1:10													4	5:20
80	80	1:10													14	15:20
80	90	1:10													23	24:20
80	100	1:10													37	38:20
80	110	1:10													52	53:20
80	120	1:00												1	65	67:20
limit line																
80	130	1:00												5	79	85:20
80	140	1:00												9	92	102:20
80	150	1:00												20	98	119:20
80	160	1:00												30	103	134:20

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
80	170	1:00												39	109	149:20
80	180	1:00												47	115	163:20
80	190	1:00												55	120	176:20
90	44	1:30													0	1:30
90	50	1:20													5	6:30
90	60	1:20													13	14:30
90	70	1:20													28	29:30
90	80	1:20													40	41:30
90	90	1:10												9	48	58:30
90	100	1:10												17	59	77:30
90	110	1:10												24	70	95:30
90	120	1:10												31	86	118:30
limit line																
90	130	1:10												43	95	139:30
90	140	1:10												57	101	159:30
90	150	1:00											3	66	108	178:30
90	160	1:00											6	75	114	196:30
100	33	1:40													0	1:40
100	35	1:30													1	2:40
100	40	1:30													9	10:40
100	50	1:30													22	23:40
100	60	1:20												7	28	36:40
100	70	1:20												13	38	52:40
100	80	1:20												24	46	71:40
100	90	1:20												36	58	95:40
100	100	1:10											4	41	71	117:40

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
limit line																
100	110	1:10											12	42	88	143:40
100	120	1:10											19	53	96	169:40
100	130	1:10											25	64	103	193:40
100	140	1:10											30	75	110	216:40
110	23	1:50													0	1:50
110	25	1:40													2	3:50
110	30	1:40													6	7:50
110	35	1:40													15	16:50
110	40	1:30												1	23	25:50
110	50	1:30												14	24	39:50
110	60	1:30												24	33	58:50
110	70	1:20											7	27	41	76:50
110	80	1:20											12	37	55	105:50
110	90	1:20											21	41	69	132:50
110	100	1:20											32	41	87	161:50
limit line																
110	110	1:20											41	54	95	191:50
110	120	1:10										8	41	67	103	220:50
110	130	1:10										15	40	80	111	247:50
110	140	1:10										20	50	82	119	272:50
120	19	2:00													0	2:00
120	20	1:50													2	4:00
120	25	1:50													8	10:00
120	30	1:40												3	14	19:00
120	35	1:40												6	22	30:00
120	40	1:40												15	23	40:00

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
120	50	1:30											6	24	25	57:00
120	60	1:30											17	24	38	81:00
120	70	1:20										1	24	33	48	108:00
120	80	1:20										7	27	41	63	140:00
limit line																
120	90	1:20										11	37	41	81	172:00
120	100	1:20										19	41	52	92	206:00
120	110	1:20										29	41	67	101	240:00
120	120	1:20										38	41	81	110	272:00
130	16	2:10													0	2:10
130	20	2:00													8	10:10
130	25	1:50												5	10	17:10
130	30	1:50												10	19	31:10
130	35	1:40											4	14	24	44:10
130	40	1:40											6	23	24	55:10
130	50	1:40											22	24	28	76:10
130	60	1:30										11	23	25	41	102:10
130	70	1:30										19	24	39	54	138:10
limit line																
130	80	1:20									1	24	34	41	73	175:10
130	90	1:20									6	28	41	47	91	215:10
130	100	1:20									9	38	41	64	99	253:10
130	110	1:20									17	41	41	80	108	289:10
130	120	1:20									27	40	55	82	116	322:10
140	13	2:20													0	2:20
140	15	2:10													2	4:20
140	20	2:00												4	10	16:20

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
140	25	1:50											1	11	13	27:20
140	30	1:50											7	11	24	44:20
140	35	1:40										1	10	21	24	58:20
140	40	1:40										4	16	24	24	70:20
140	50	1:40										15	23	24	32	96:20
140	60	1:30									4	24	24	29	45	128:20
140	70	1:30									13	24	27	41	68	175:20
limit line																
140	80	1:30									20	24	40	41	91	218:20
140	90	1:20								1	24	36	40	58	99	260:20
140	100	1:20								4	30	41	41	75	107	300:20
150	11	2:30													0	2:30
150	15	2:10												1	6	9:30
150	20	2:10												10	10	22:30
150	25	2:00											8	10	18	38:30
150	30	1:50										4	10	16	24	56:30
150	35	1:50										9	13	23	24	71:30
150	40	1:40									2	10	22	24	24	84:30
150	45	1:40									4	17	24	24	27	98:30
150	50	1:40									7	24	24	23	35	115:30
150	55	1:40									15	23	24	26	46	136:30
150	60	1:40									21	24	24	34	59	164:30
limit line																
150	70	1:30								7	24	24	33	41	85	216:30
150	80	1:30								15	23	31	41	47	105	264:30
150	90	1:30								20	26	41	41	67	111	308:30
155	10	2:35													0	2:35

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
155	15	2:15												2	8	12:35
155	20	2:05											2	11	10	25:35
155	25	1:55										1	10	11	19	43:35
155	30	1:55										8	10	18	24	62:35
155	35	1:45									2	11	15	24	24	78:35
155	40	1:45									6	12	24	24	23	91:35
155	45	1:45									8	21	24	24	28	107:35
155	50	1:45									15	24	24	23	37	125:35
155	55	1:35								1	22	24	24	27	54	154:35
155	60	1:35								6	24	24	23	37	69	185:35
limit line																
155	70	1:35								16	24	24	36	41	95	238:35
155	80	1:35								24	24	33	41	52	110	286:35
155	90	1:25							5	24	31	41	40	72	117	332:35
160	9	2:40													0	2:40
160	10	2:30													1	3:40
160	15	2:20												4	8	14:40
160	20	2:10											5	11	10	28:40
160	25	2:00										5	10	10	22	49:40
160	30	1:50									1	10	11	21	23	68:40
160	35	1:50									6	10	19	24	24	85:40
160	40	1:50									10	15	24	24	24	99:40
160	45	1:40								2	11	24	24	24	29	116:40
160	50	1:40								4	19	24	24	23	46	142:40
limit line																
160	55	1:40								7	24	24	24	30	63	174:40
160	60	1:40								14	24	24	24	39	78	205:40

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
160	70	1:30							1	24	24	24	38	41	105	259:40
160	80	1:30							9	24	24	37	41	57	116	310:40
160	90	1:30							15	23	35	41	41	77	122	356:40
165	9	2:45													0	2:45
165	10	2:35													2	4:45
165	15	2:15											1	4	10	17:45
165	20	2:05										1	7	10	11	31:45
165	25	2:05										8	10	11	23	54:45
165	30	1:55									5	10	10	24	24	75:45
165	35	1:55									10	10	22	24	24	92:45
165	40	1:45								3	10	19	24	24	24	106:45
165	45	1:45								6	15	24	23	24	32	126:45
165	50	1:45								8	23	24	24	23	56	160:45
limit line																
165	55	1:45								16	24	23	24	32	74	195:45
165	60	1:45								23	24	24	24	40	88	225:45
165	70	1:35							10	24	24	24	41	43	115	283:45
165	80	1:35							18	24	24	41	41	61	122	333:45
170	8	2:50													0	2:50
170	10	2:40													3	5:50
170	15	2:20											3	4	11	20:50
170	20	2:10										2	9	10	12	35:50
170	25	2:00									1	10	10	13	24	60:50
170	30	2:00									9	10	12	24	24	81:50
170	35	1:50								4	10	11	24	23	24	98:50
170	40	1:50								7	10	23	23	24	24	113:50

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
170	45	1:50								10	18	24	24	24	41	143:50
170	50	1:40							2	13	24	24	24	24	67	180:50
limit line																
170	55	1:40							3	21	24	24	24	33	84	215:50
170	60	1:40							8	24	23	24	26	41	99	247:50
170	70	1:40							19	24	24	27	41	47	122	306:50
170	80	1:30						4	24	24	26	41	41	73	123	358:50
175	8	2:55													0	2:55
175	10	2:45													4	6:55
175	15	2:25											4	6	10	22:55
175	20	2:15										4	10	10	14	40:55
175	25	2:05									5	10	10	15	23	65:55
175	30	1:55								2	10	10	15	24	24	87:55
175	35	1:55								7	10	15	23	24	24	105:55
175	40	1:45							1	10	12	24	24	24	25	122:55
limit line																
175	45	1:45							4	10	22	24	24	24	52	162:55
175	50	1:45							6	17	24	24	24	25	79	201:55
175	55	1:45							8	24	24	24	24	35	94	235:55
175	60	1:45							16	24	24	24	28	41	109	268:55
175	70	1:35						4	24	24	24	30	41	57	123	329:55
175	80	1:35						13	24	24	30	41	41	85	123	383:55
180	7	3:00													0	3:00
180	10	2:40												1	4	8:00
180	15	2:20										1	4	7	11	26:00
180	20	2:10									1	6	10	10	16	46:00
180	25	2:10									8	10	10	17	24	72:00

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
180	30	2:00								6	10	10	17	24	24	94:00
180	35	1:50							1	10	10	17	24	24	24	113:00
180	40	1:50							5	10	15	24	24	24	35	140:00
limit line																
180	45	1:50							8	12	24	24	23	24	64	182:00
180	50	1:50							10	21	24	24	24	27	88	221:00
180	55	1:40						1	16	24	23	24	24	38	104	257:00
180	60	1:40						2	23	24	24	23	31	41	121	292:00
180	70	1:40						13	24	24	24	33	41	69	123	354:00
185	7	3:05													0	3:05
185	10	2:45												3	4	10:05
185	15	2:25										3	4	8	10	28:05
185	20	2:15									3	7	10	10	17	50:05
185	25	2:05								1	10	10	10	20	23	77:05
185	30	2:05								9	10	10	21	23	24	100:05
185	35	1:55							5	10	10	20	24	24	24	120:05
185	40	1:55							9	10	19	23	24	24	45	157:05
limit line																
185	45	1:45						2	10	15	24	24	24	24	75	201:05
185	50	1:45						4	11	24	24	24	24	29	98	241:05
185	55	1:45						5	20	24	24	24	24	39	116	279:05
185	60	1:45						10	23	24	24	24	33	50	123	314:05
185	70	1:45						22	24	24	24	35	41	81	123	377:05
190	7	3:10													0	3:10
190	10	2:50												4	4	11:10
190	15	2:30										4	4	9	10	30:10
190	20	2:20									4	9	10	10	19	55:10

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

PTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
90	25	2:10								4	11	10	10	21	24	83:10
90	30	2:00							3	10	10	10	23	24	23	106:10
90	35	2:00							8	11	10	23	24	23	26	128:10
90	40	1:50						3	10	10	22	24	23	24	57	176:10
mit line																
90	45	1:50						6	10	19	24	24	24	24	87	221:10
90	50	1:50						8	15	24	24	24	24	30	110	262:10
90	55	1:50						10	23	24	24	24	24	45	123	300:10
90	60	1:50						18	24	24	24	24	34	63	123	337:10
90	70	1:40					7	24	24	24	24	38	41	94	123	402:10
95	7	3:15													0	3:15
95	10	2:45											1	4	4	12:15
95	15	2:25									1	4	5	10	10	33:15
95	20	2:15								2	4	10	10	10	21	60:15
95	25	2:15								8	10	10	10	23	24	88:15
95	30	2:05							6	10	10	12	24	24	24	113:15
95	35	1:55						2	10	10	13	23	24	24	35	144:15
95	40	1:55						6	11	11	24	24	24	24	67	194:15
mit line																
95	45	1:55						10	10	23	24	23	24	24	99	240:15
95	50	1:45					2	10	19	24	24	24	24	32	121	283:15
95	55	1:45					3	15	24	24	23	24	26	59	123	324:15
95	60	1:45					4	23	24	23	24	24	37	75	123	360:15
100	6	3:20													0	3:20
100	10	2:50											2	4	4	13:20
100	15	2:30									3	4	5	10	10	35:20
100	20	2:20								3	6	10	10	10	22	64:20

10:49 AM TUE., 16 APR., 1985 TBLP7 HVAL13 (FEET)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
200	25	2:10							2	9	10	10	12	24	24	94:20
200	30	2:10							10	10	10	14	24	24	24	119:20
200	35	2:00						6	10	10	15	24	24	24	45	161:20
limit line																
200	40	2:00						10	10	15	24	24	24	24	78	212:20
200	45	1:50					3	10	14	23	24	24	24	24	111	260:20
200	50	1:50					6	10	23	24	24	24	24	43	123	304:20
200	55	1:50					7	19	24	24	24	24	28	70	123	346:20
200	60	1:50					11	24	24	24	24	24	39	87	123	383:20
205	6	3:25													0	3:25
205	10	2:55											3	4	4	14:25
205	15	2:35									4	4	7	10	10	38:25
205	20	2:15							1	4	7	10	10	10	24	69:25
205	25	2:15							4	10	10	11	14	23	24	99:25
205	30	2:05						3	10	10	10	17	24	24	24	125:25
205	35	2:05						10	10	10	18	24	24	24	55	178:25
limit line																
205	40	1:55					4	10	10	19	23	24	24	24	91	232:25
205	45	1:55					7	10	17	24	24	24	24	25	122	280:25
205	50	1:55					10	13	24	24	24	24	24	57	123	326:25
205	55	1:45				1	10	23	24	24	24	24	30	81	123	367:25
205	60	1:45				2	18	24	24	23	24	25	41	100	123	407:25
210	6	3:30													0	3:30
210	10	3:00											4	4	5	16:30
210	15	2:30								1	4	5	7	10	10	40:30
210	20	2:20							2	4	9	10	10	12	24	74:30
210	25	2:10						1	7	10	10	10	16	24	24	105:30

10:49 AM TUE., 16 APR., 1985 TBLP7 HYAL13 (FEET)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
210	30	2:10						7	10	10	10	19	24	24	29	136:30
210	35	2:00					3	10	10	11	21	24	23	24	67	196:30
limit line																
210	40	2:00					8	10	10	22	24	23	24	24	103	251:30
210	45	1:50				1	10	10	21	24	24	23	24	38	123	301:30
210	50	1:50				4	10	17	24	24	24	24	24	72	123	349:30
210	55	1:50				5	14	24	24	23	24	24	32	95	123	391:30
210	60	1:50				6	22	24	24	24	24	27	41	113	123	431:30
215	6	3:35													0	3:35
215	10	2:55										1	4	4	6	18:35
215	15	2:35								3	4	4	9	10	10	43:35
215	20	2:25							4	4	10	10	10	13	24	78:35
215	25	2:15						2	9	10	10	10	18	24	24	110:35
215	30	2:15						10	10	10	11	22	23	24	38	151:35
limit line																
215	35	2:05					7	10	10	11	23	24	24	24	77	213:35
215	40	1:55				2	10	10	11	24	24	24	24	23	115	270:35
215	45	1:55				5	10	11	23	24	24	24	24	51	123	322:35
215	50	1:55				8	10	21	24	24	24	24	24	85	124	371:35
215	60	1:45			1	12	24	24	24	24	23	29	46	123	124	457:35
220	6	3:40													0	3:40
220	10	3:00										2	4	4	6	19:40
220	15	2:40								4	4	4	10	10	10	45:40
220	20	2:20						1	4	6	10	10	10	15	24	83:40
220	25	2:20						4	10	10	10	10	21	24	24	116:40
220	30	2:10					4	10	10	10	11	24	23	24	49	168:40
limit line																
220	35	2:00				1	10	10	10	13	24	24	24	24	89	232:40

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
220	40	2:00				6	10	10	14	24	24	24	24	28	123	290:40
220	45	2:00				9	10	14	24	24	24	24	23	66	123	344:40
220	50	1:50			2	10	11	24	24	24	24	24	24	99	123	392:40
220	55	1:50			3	10	22	24	24	24	24	24	37	120	123	438:40
225	5	3:45													0	3:45
225	10	3:05										3	4	4	7	21:45
225	15	2:35							1	4	5	4	11	10	10	48:45
225	20	2:25						3	4	7	10	10	10	17	24	88:45
225	25	2:15					2	5	10	11	10	10	22	24	24	121:45
225	30	2:15					7	10	10	11	13	24	24	23	59	184:45
limit line																
225	35	2:05				4	10	11	10	16	24	24	24	23	101	250:45
225	40	2:05				9	11	10	17	24	24	24	24	40	123	309:45
225	45	1:55			3	10	10	18	24	24	23	24	24	80	123	366:45
225	50	1:55			6	10	15	24	24	24	24	24	25	114	123	416:45
225	55	1:55			7	13	24	24	23	24	24	24	51	123	123	463:45
230	5	3:50													0	3:50
230	10	3:10										4	4	4	8	23:50
230	15	2:40							3	4	4	6	10	10	12	52:50
230	20	2:30						4	4	8	11	10	10	18	24	92:50
230	25	2:20					3	8	10	10	10	11	24	24	25	128:50
230	30	2:10				1	10	10	10	10	16	24	24	24	69	201:50
limit line																
230	35	2:10				8	10	10	10	20	24	23	24	24	112	268:50
230	40	2:00			3	10	10	11	21	24	23	24	24	54	123	330:50
230	45	2:00			7	10	10	21	24	24	24	24	24	92	123	386:50
230	50	2:00			10	10	19	24	24	24	24	24	34	120	123	439:50

10:49 AM TUE., 16 APR., 1985 TBLP7 HVAL13 (FEET)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
230	55	1:50	1	10	17	24	24	24	24	23	24	67	123	123		487:50
235	5	3:55													0	3:55
235	10	3:05									1	4	4	4	9	25:55
235	15	2:45							4	4	4	7	10	11	13	56:55
235	20	2:25					2	4	4	9	10	11	10	20	24	97:55
235	25	2:15				1	4	9	10	10	10	13	24	24	34	142:55
235	30	2:15				4	10	10	11	10	18	24	24	24	80	218:55
limit line																
235	35	2:05			2	10	10	10	10	22	24	24	24	26	121	286:55
235	40	2:05			7	10	10	11	24	24	24	23	24	68	123	351:55
235	45	1:55		1	10	10	11	24	24	24	24	23	24	107	123	408:55
235	50	1:55		3	11	10	23	24	24	24	24	24	24	46	123	123 462:55
240	5	4:00													0	4:00
240	10	3:10									2	4	4	5	9	28:00
240	15	2:40						1	4	5	4	8	10	10	14	60:00
240	20	2:30					3	4	5	10	10	11	10	22	23	102:00
240	25	2:20				2	5	10	10	10	10	16	23	24	43	157:00
limit line																
240	30	2:20				8	10	10	10	10	21	24	24	24	90	235:00
240	35	2:10			5	10	11	10	11	24	24	24	24	36	123	306:00
240	40	2:00		1	10	10	10	14	24	24	24	24	23	81	123	372:00
240	45	2:00		5	10	10	15	24	23	24	24	24	29	117	123	432:00
240	50	2:00		8	10	14	23	24	24	24	24	24	24	62	123	123 487:00
245	5	4:05													0	4:05
245	10	3:15									3	4	4	5	9	29:05
245	15	2:45						3	4	4	4	9	10	10	16	64:05
245	20	2:25				1	4	4	6	10	10	10	11	23	24	107:05

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
245	25	2:25				4	6	10	10	11	10	17	24	24	52	172:05
limit line																
245	30	2:15			1	10	10	10	11	10	23	24	24	24	101	252:05
245	35	2:15			9	10	10	10	15	24	24	23	24	50	123	326:05
245	40	2:05		5	10	10	10	17	24	24	24	24	24	94	123	393:05
245	45	2:05		9	10	10	18	24	24	24	24	24	37	124	123	455:05
245	50	1:55	1	11	10	17	24	24	24	24	24	24	77	123	123	510:05
250	5	4:10													0	4:10
250	10	3:20									4	4	5	4	10	31:10
250	15	2:50						4	4	4	4	11	10	10	17	68:10
250	20	2:30				2	4	4	8	10	10	10	12	24	24	112:10
250	25	2:20			1	5	8	10	10	10	10	19	24	24	62	187:10
limit line																
250	30	2:20			5	10	10	10	10	12	24	24	24	24	112	269:10
250	35	2:10		3	10	10	10	10	18	23	24	24	24	63	123	346:10
250	40	2:10		9	10	10	10	21	23	24	24	24	24	108	123	414:10
250	45	2:00	3	10	10	10	22	24	24	24	23	24	54	123	123	478:10
250	50	2:00	5	11	10	21	24	24	24	24	24	24	92	124	123	534:10
255	5	4:15													0	4:15
255	10	3:15								1	4	4	5	5	10	33:15
255	15	2:45					1	4	4	5	5	10	10	10	18	71:15
255	20	2:35				4	4	4	9	10	10	10	13	24	24	116:15
255	25	2:25			3	4	10	10	10	10	10	22	24	23	72	202:15
limit line																
255	30	2:15		1	7	10	10	11	10	15	23	24	24	29	119	287:15
255	35	2:15		6	11	10	10	10	20	24	24	24	24	75	124	366:15
255	40	2:05	2	10	10	11	10	24	24	23	24	24	29	117	123	435:15
255	45	2:05	6	11	10	12	24	23	24	24	24	24	68	123	123	500:15

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
255	50	2:05	9	11	12	23	24	24	24	24	24	24	109	123	123		558:15
260	5	4:10														1	5:20
260	10	3:20									2	4	5	4	6	10	35:20
260	15	2:50						3	4	4	4	6	10	11	10	19	75:20
260	20	2:30				1	4	4	5	10	10	10	10	15	24	27	124:20
260	25	2:20			1	4	5	10	10	10	10	10	24	24	24	81	217:20
limit line																	
260	30	2:20			2	10	10	10	10	10	18	23	24	24	37	123	305:20
260	35	2:20			10	10	10	10	11	23	24	24	23	24	88	123	384:20
260	40	2:10		6	10	10	10	14	24	24	24	23	24	38	123	123	457:20
260	45	2:10		10	11	10	15	24	24	24	24	24	23	83	123	123	522:20
265	5	4:15														1	5:25
265	10	3:25									3	4	5	4	6	11	37:25
265	15	2:55						4	4	4	4	8	10	10	10	21	79:25
265	20	2:35				3	4	4	6	10	10	10	10	17	23	36	137:25
265	25	2:25			2	4	7	10	10	11	10	12	24	23	24	93	234:25
limit line																	
265	30	2:25			5	10	10	10	11	10	20	23	24	24	48	124	323:25
265	35	2:15		4	10	10	10	10	13	23	24	24	24	24	101	123	404:25
265	40	2:15		10	10	10	10	17	24	24	24	24	23	53	123	123	479:25
265	45	2:05	4	10	10	11	19	24	24	23	24	24	24	99	123	123	546:25
270	5	4:20														2	6:30
270	10	3:30									4	5	4	4	7	10	38:30
270	15	2:50					1	4	4	4	5	8	10	10	10	22	82:30
270	20	2:40				4	4	4	7	11	10	10	10	18	24	43	149:30
270	25	2:30			4	4	8	11	10	10	10	14	24	24	24	103	250:30
limit line																	
270	30	2:20		1	8	10	10	10	10	10	23	24	23	24	61	123	341:30

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
270	35	2:20			7	11	10	10	10	15	24	24	24	24	27	111	123	424:30
270	40	2:10		4	10	10	10	10	20	24	24	24	24	24	66	123	124	501:30
270	45	2:10		8	10	10	11	22	24	24	24	24	24	27	110	124	123	569:30
275	5	4:25															2	6:35
275	10	3:25									1	4	5	4	4	8	10	40:35
275	15	2:55						3	4	4	4	4	9	11	10	10	24	87:35
275	20	2:35				2	4	4	4	8	10	11	10	10	20	24	51	162:35
limit line																		
275	25	2:25			1	4	5	10	10	10	10	10	16	24	24	26	111	265:35
275	30	2:25			3	9	10	10	10	11	11	24	24	23	24	73	123	359:35
275	35	2:15		1	10	10	10	10	11	18	24	24	23	24	35	118	123	445:35
275	40	2:15		8	10	10	10	10	23	24	24	24	24	24	81	123	123	522:35
275	45	2:05	2	10	10	10	13	24	24	24	24	23	24	38	117	123	123	593:35
280	5	4:30															3	7:40
280	10	3:30									2	5	4	4	4	9	10	42:40
280	15	3:00						4	4	4	4	5	10	10	10	11	24	90:40
280	20	2:40				3	4	4	4	10	10	10	11	10	21	24	59	174:40
limit line																		
280	25	2:30			3	4	6	10	10	10	10	10	19	24	23	34	114	281:40
280	30	2:20		1	5	10	10	10	10	10	14	24	24	23	24	86	123	378:40
280	35	2:20		5	10	10	10	10	10	22	23	24	24	24	44	122	123	465:40
280	40	2:10	1	10	10	11	10	13	24	23	24	24	24	24	96	123	123	544:40
280	45	2:10	6	10	10	10	17	24	23	24	24	24	24	48	122	123	124	617:40
285	5	4:35															3	7:45
285	10	3:35									3	5	4	4	4	9	11	44:45
285	15	2:55					1	4	4	4	4	6	10	10	10	13	24	94:45
285	20	2:35			1	4	4	4	5	10	10	10	10	10	24	24	68	188:45

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN)															TOTAL ASCNT TIME (M:S)
			160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	
limit line																			
285	25	2:35				4	4	8	10	10	10	10	11	20	24	24	40	117	296:45
285	30	2:25			2	7	10	10	10	10	11	16	24	24	23	24	98	123	396:45
285	35	2:25			8	11	10	10	10	10	24	24	24	24	24	56	123	124	486:45
285	40	2:15		5	10	10	10	11	16	24	23	24	24	24	28	108	123	123	567:45
285	45	2:15		10	10	10	10	20	24	24	24	24	24	24	23	63	123	123	124 640:45
290	5	4:40																4	8:50
290	10	3:40										4	5	4	4	4	10	10	45:50
290	15	3:00						2	5	4	4	4	7	10	10	10	14	24	98:50
290	20	2:40				2	4	4	4	7	10	10	10	10	12	24	24	77	202:50
limit line																			
290	25	2:30			2	4	4	9	10	10	11	10	10	22	24	24	49	120	313:50
290	30	2:30			4	9	10	10	10	10	10	19	24	24	24	28	106	123	415:50
290	35	2:20		2	10	10	10	10	11	13	24	24	23	24	24	71	123	123	506:50
290	40	2:20		9	10	10	10	10	20	24	24	23	24	24	37	114	123	124	590:50
290	45	2:10	4	10	10	10	10	24	24	23	24	24	24	24	79	123	123	124	664:50
295	5	4:35															1	4	9:55
295	10	3:35									1	4	5	4	4	5	10	10	47:55
295	15	3:05						4	4	4	4	4	8	10	10	10	16	24	102:55
295	20	2:45				3	5	4	4	8	10	10	10	10	13	24	24	88	217:55
limit line																			
295	25	2:35			3	5	4	10	11	10	10	10	11	24	24	23	58	123	330:55
295	30	2:25		1	5	10	10	10	10	10	11	21	24	24	24	36	110	123	433:55
295	35	2:25		6	10	10	10	10	10	16	24	24	24	24	24	84	123	124	527:55
295	40	2:15	3	10	10	10	10	10	23	24	24	24	23	24	48	119	123	123	612:55
300	5	4:40															1	4	10:00
300	10	3:40									2	4	5	4	4	6	10	10	50:00
300	15	3:00					1	4	4	4	4	4	9	10	10	11	17	24	107:00

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN)																		TOTAL ASCNT TIME (M:S)
			180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	
300	20	2:40					1	4	4	4	4	10	10	10	10	10	15	24	24	97	232:00
limit line																					
300	25	2:30				1	4	4	7	10	10	10	10	10	13	24	24	24	70	123	349:00
300	30	2:30				3	6	11	10	10	10	10	10	24	24	24	24	45	115	123	454:00
300	35	2:30				9	11	10	10	10	10	19	24	24	24	24	23	100	123	123	549:00
300	40	2:20			7	10	10	10	10	12	24	24	24	24	24	23	59	123	124	123	636:00
limit line																					
310	6	4:30															1	3	5	4	18:10
310	10	3:50											4	5	4	4	4	7	10	10	53:10
310	15	3:10							4	4	4	4	4	5	10	10	10	10	21	34	125:10
310	20	2:50					4	4	4	4	6	10	10	10	11	10	19	23	33	107	260:10
310	25	2:40				4	4	4	10	10	10	10	10	11	17	24	23	24	92	124	382:10
310	30	2:30			2	4	10	10	11	10	10	10	15	24	24	24	24	63	123	123	492:10
310	35	2:30			7	10	10	10	10	10	11	24	24	24	24	24	42	110	123	123	591:10
310	40	2:20		4	10	10	10	11	10	18	24	24	24	24	24	24	90	123	123	123	681:10
limit line																					
320	6	4:40															2	4	4	4	19:20
320	10	3:50										2	4	5	4	4	4	8	10	11	57:20
320	15	3:10						2	4	4	4	4	5	7	10	10	10	10	24	45	144:20
320	20	2:50				3	4	4	4	4	9	10	10	10	10	10	23	24	48	110	288:20
320	25	2:40			3	4	4	7	10	11	10	10	10	10	21	24	24	40	100	123	416:20
320	30	2:30		1	5	7	10	10	11	10	10	10	20	24	24	24	23	91	123	123	531:20
320	35	2:30		4	10	10	10	10	10	11	17	23	24	24	24	24	62	120	123	123	634:20
320	40	2:20	2	10	10	10	10	10	12	24	23	24	24	24	24	40	106	123	123	124	728:20

APPENDIX G

FINAL DECOMPRESSION TABLES (HVAL 21)

Tables in feet with 10 FSW Stop Depth Increment and in meters with 3 MSW Stop Depth Increments

Tables of different depth grouping are separated by a solid line. Within each depth grouping is a limit line. Profiles above the limit line are the only ones used in planning a dive. Profiles below the limit line are for emergency use only. Each profile is backed up by profiles down to 20 FSW (or 6 MSW) deeper and up to 20 minutes longer.

Rules for Using 0.7 ATA Constant PO_2 in Helium Decompression Tables

1. These tables are designed to be used with a MK 15 or MK 16 UBA (or any other constant PO_2 closed circuit UBA) with a setpoint of 0.7 ATA or higher and a helium diluent. The diluent may be 100% helium or any appropriate HeO_2 mixture.

2. To minimize the amount of nitrogen in the breathing loop, flush the UBA well with HeO_2 during set up and exhale completely before going on the UBA.

3. Tables are grouped by depth and within each depth group is a limit line. These tables are designed to be dove right up to the limit line. Schedules below the limit line are provided for unforeseen circumstances where a diver might experience an inadvertent downward excursion or for some unforeseen reason overstays his planned bottom time. All schedules below 300 FSW are below the limit line.

4. Tables are selected according to maximum depth obtained during the dive and bottom time (time from leaving surface to start of decompression).

5. Rules during ascent are the same as for standard air tables.

6. When selecting the proper decompression table, all dives done within the past 12 hours must be considered. The following rules apply for the various situations which may occur.

   a. The last dive was 12 hours or more ago.

      Select the table for the maximum depth attained and the total bottom time of the current dive.

   b. All dives within the past 12 hours were from these tables.

      Add the bottom time of the current dive to the sum of the bottom times for all dives within the past 12 hours to get the adjusted bottom time. Use the maximum depth attained within the past 12 hours and the adjusted bottom time to select the appropriate table.

   c. All dives during the past 12 hours were from the Navy Standard Air Tables.

      Compute a residual nitrogen time as if the currently planned dive were an air dive. Add this residual nitrogen time to the total bottom time of the currently planned HeO_2 dive to get the adjusted total bottom time. Use the maximum depth of the current dive and the adjusted total bottom time to select the appropriate table.

Rules for Using 0.7 ATA Constant PO_2 in Helium Decompression Tables (Continued)

d. Dives within the past 12 hours consisted of dives from more than one of the various tables in the Diving Manual or from tables other than these or the standard air tables.

Use the procedure in paragraph b. above.

e. If an air dive is planned following using these tables, an air repetitive group for use with future air dives may be computed as follows:

Add the bottom times of all HeO_2 dives done within 12 hours of surfacing from the final dive from these tables to get an adjusted bottom time. Find the air table with the maximum depth attained during the past 12 hours and the adjusted bottom time. The repetitive group from this air table may then be used as the surfacing repetitive group from the last dive. The surface interval credit table is used to find the repetitive group at the end of the current surface interval and the appropriate residual nitrogen time for the current dive.

7. The last stop may be taken at 20 FSW if desired. After completing the prescribed 20 FSW stop, remain at any depth between 10 FSW and 20 FSW inclusive for the 10 FSW stop time as noted in the appropriate decompression table.

8. In emergency situations (e.g. UBA floodout during decompression) air may be breathed for any part or all of the decompression without modification of the decompression table. If this is done, the diver should be closely observed for signs of decompression sickness for 2 hours following the dive but need not be treated unless symptoms arise.

MK 15/16 0.7 ATA PO_2
in He Decompression Tables

Depth in Feet of Sea Water (FSW)
Stops in 10 FSW Increments

NOTE: Time/Date reflects only when tables actually printed, not version.

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(HVAL21- HELIUM)

TISSUE HALF-TIMES

I	5 MIN 1.00 SDR	10 MIN .83 SDR	20 MIN .71 SDR	40 MIN .83 SDR	80 MIN .83 SDR	120 MIN .83 SDR			
SW	115.000	96.000	77.000	65.000	55.000	48.000			
SW	126.000	107.000	88.000	76.000	66.000	59.000			
SW	137.000	118.000	99.000	87.000	77.000	70.000			
SW	148.000	129.000	110.000	98.000	88.000	81.000			
SW	159.000	140.000	121.000	109.000	99.000	92.000			
SW	170.000	151.000	132.000	120.000	110.000	103.000			
SW	181.000	162.000	143.000	131.000	121.000	114.000			
SW	192.000	173.000	154.000	142.000	132.000	125.000			
SW	203.000	184.000	165.000	153.000	143.000	136.000			
SW	214.000	195.000	176.000	164.000	154.000	147.000			
SW	225.000	206.000	187.000	175.000	165.000	158.000			
SW	236.000	217.000	198.000	186.000	176.000	169.000			
SW	247.000	228.000	209.000	197.000	187.000	180.000			
SW	258.000	239.000	220.000	208.000	198.000	191.000			
SW	269.000	250.000	231.000	219.000	209.000	202.000			
SW	280.000	261.000	242.000	230.000	220.000	213.000			
SW	291.000	272.000	253.000	241.000	231.000	224.000			
SW	302.000	283.000	264.000	252.000	242.000	235.000			
SW	313.000	294.000	275.000	263.000	253.000	246.000			
SW	324.000	305.000	286.000	274.000	264.000	257.000			
SW	335.000	316.000	297.000	285.000	275.000	268.000			
SW	346.000	327.000	308.000	296.000	286.000	279.000			
SW	357.000	338.000	319.000	307.000	297.000	290.000			
SW	368.000	349.000	330.000	318.000	308.000	301.000			
SW	379.000	360.000	341.000	329.000	319.000	312.000			
SW	390.000	371.000	352.000	340.000	330.000	323.000			
SW	401.000	382.000	363.000	351.000	341.000	334.000			
SW	412.000	393.000	374.000	362.000	352.000	345.000			
SW	423.000	404.000	385.000	373.000	363.000	356.000			
SW	434.000	415.000	396.000	384.000	374.000	367.000			

BLOOD PARAMETERS

(PRESSURE IN FSW; 33 FSW=1 ATA)

2	PH2O	PVCO2	PVO2	AMBAO2	PBOVP
0	0.00	2.30	2.00	0.00	0.000

9:57 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (FEET)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
40	370	0:40													0	0:40
limit line																
40	380	0:40													0	0:40
40	390	0:40													0	0:40
50	205	0:50													0	0:50
50	210	0:40													3	3:50
50	220	0:40													9	9:50
50	230	0:40													15	15:50
50	240	0:40													20	20:50
50	250	0:40													25	25:50
limit line																
50	260	0:40													29	29:50
50	270	0:40													34	34:50
50	280	0:40													38	38:50
50	290	0:40													42	42:50
50	300	0:40													45	45:50
50	310	0:40													49	49:50
50	320	0:40													52	52:50
50	330	0:40													55	55:50
50	340	0:40													58	58:50
50	350	0:40													61	61:50
50	360	0:40													63	63:50
50	370	0:40													66	66:50
50	380	0:40													68	68:50
50	390	0:40													70	70:50
60	133	1:00													0	1:00
60	140	0:50													8	9:00

9:57 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (FEET)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
60	150	0:50													20	21:00
60	160	0:50													30	31:00
60	170	0:50													40	41:00
limit line																
60	180	0:50													50	51:00
60	190	0:50													59	60:00
60	200	0:50													67	68:00
60	210	0:50													75	76:00
60	220	0:50													83	84:00
60	230	0:50													90	91:00
60	240	0:50													97	98:00
60	250	0:50													103	104:00
60	260	0:50													109	110:00
60	270	0:40												2	112	115:00
60	280	0:40												7	113	121:00
60	290	0:40												12	113	126:00
60	300	0:40												17	113	131:00
60	310	0:40												21	113	135:00
60	320	0:40												25	113	139:00
60	330	0:40												29	113	143:00
60	340	0:40												33	113	147:00
60	350	0:40												37	113	151:00
60	360	0:40												40	113	154:00
60	370	0:40												43	113	157:00
60	380	0:40												46	113	160:00
60	390	0:40												49	113	163:00

9:57 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (FEET)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
70	81	1:10													0	1:10
70	90	1:00													6	7:10
70	100	1:00													13	14:10
70	110	1:00													19	20:10
70	120	1:00													35	36:10
70	130	1:00													50	51:10
70	140	1:00													65	66:10
limit line																
70	150	1:00													79	80:10
70	160	1:00													92	93:10
70	170	1:00													104	105:10
70	180	0:50												7	109	117:10
70	190	0:50												14	113	128:10
70	200	0:50												25	112	138:10
70	210	0:50												34	113	148:10
70	220	0:50												44	112	157:10
70	230	0:50												52	113	166:10
70	240	0:50												60	113	174:10
70	250	0:50												68	113	182:10
70	260	0:50												76	112	189:10
70	270	0:50												83	112	196:10
80	51	1:20													0	1:20
80	60	1:10													6	7:20
80	70	1:10													14	15:20
80	80	1:10													25	26:20
80	90	1:10													33	34:20

9:57 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (FEET)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
80	100	1:00												3	43	47:20
80	110	1:00												9	58	68:20
80	120	1:00												14	72	87:20
limit line																
80	130	1:00												19	85	105:20
80	140	1:00												23	99	123:20
80	150	1:00												33	105	139:20
80	160	1:00												43	111	155:20
80	170	1:00												55	113	169:20
80	180	1:00												69	113	183:20
80	190	1:00												82	113	196:20
90	37	1:30													0	1:30
90	40	1:20													4	5:30
90	50	1:20													15	16:30
90	60	1:10												1	23	25:30
90	70	1:10												7	31	39:30
90	80	1:10												12	38	51:30
90	90	1:10												23	42	66:30
90	100	1:10												31	60	92:30
90	110	1:00												1	37	77	116:30
90	120	1:00												7	37	93	138:30
limit line																
90	130	1:00												12	45	101	159:30
90	140	1:00												16	54	108	179:30
90	150	1:00												20	65	112	198:30
90	160	1:00												23	80	112	216:30
100	29	1:40													0	1:40

9:57 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (FEET)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
100	30	1:30													2	3:40
100	35	1:30													11	12:40
100	40	1:30													19	20:40
100	50	1:20												10	22	33:40
100	60	1:20												19	26	46:40
100	70	1:10											3	22	37	63:40
100	80	1:10											7	31	39	78:40
100	90	1:10											12	37	58	108:40
100	100	1:10											21	38	76	136:40
limit line																
100	110	1:10											30	37	96	164:40
100	120	1:10											36	50	102	189:40
100	130	1:00										5	37	61	109	213:40
100	140	1:00										10	37	75	113	236:40
110	22	1:50													0	1:50
110	25	1:40													3	4:50
110	30	1:40													14	15:50
110	35	1:30												3	22	26:50
110	40	1:30												12	22	35:50
110	50	1:20											4	22	22	49:50
110	60	1:20											14	22	31	68:50
110	70	1:20											21	27	37	86:50
110	80	1:10										4	22	37	54	118:50
110	90	1:10										8	30	38	75	152:50
110	100	1:10										12	37	38	95	183:50
limit line																
110	110	1:10										21	37	51	103	213:50

9:57 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (FEET)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
110	120	1:10										29	37	64	109	240:50
110	130	1:10										35	38	80	113	267:50
110	140	1:00									3	38	50	88	113	293:50
120	18	2:00													0	2:00
120	20	1:50													3	5:00
120	25	1:40												1	12	15:00
120	30	1:40												6	21	29:00
120	35	1:40												17	21	40:00
120	40	1:30											5	22	21	50:00
120	50	1:30											20	22	23	67:00
120	60	1:20										9	22	22	36	91:00
120	70	1:20										17	22	33	50	124:00
120	80	1:10									1	22	28	37	72	162:00
limit line																
120	90	1:10									5	23	37	38	93	198:00
120	100	1:10									8	32	37	49	104	232:00
120	110	1:10									12	38	37	64	111	264:00
120	120	1:10									21	37	40	83	112	295:00
130	13	2:10													0	2:10
130	15	2:00													1	3:10
130	20	2:00													9	11:10
130	25	1:50												7	17	26:10
130	30	1:40											3	14	22	41:10
130	35	1:40											8	22	22	54:10
130	40	1:30										1	18	22	22	65:10
130	50	1:30										14	22	22	26	86:10

9:57 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (FEET)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
130	60	1:20									5	22	21	25	47	122:10
130	70	1:20									13	22	23	37	69	166:10
limit line																
130	80	1:20									19	22	35	38	91	207:10
130	90	1:10								2	22	30	38	44	107	245:10
130	100	1:10								5	25	38	37	62	113	282:10
130	110	1:10								7	34	38	38	85	113	317:10
130	120	1:10								13	37	38	54	92	113	349:10
140	11	2:20													0	2:20
140	15	2:10													4	6:20
140	20	2:00												6	9	17:20
140	25	1:50											5	9	21	37:20
140	30	1:40										1	10	19	22	54:20
140	35	1:40										6	16	22	22	68:20
140	40	1:40										12	22	22	22	80:20
140	50	1:30									9	22	21	22	32	108:20
140	60	1:30									22	22	22	29	64	161:20
140	70	1:20								9	22	22	28	38	90	211:20
limit line																
140	80	1:20								16	22	26	38	38	113	255:20
140	90	1:20								21	23	37	38	61	113	295:20
140	100	1:10							2	22	34	37	38	86	113	334:20
150	9	2:30													0	2:30
150	10	2:20													1	3:30
150	15	2:10												3	6	11:30
150	20	2:00											3	9	12	26:30
150	25	1:50										2	10	12	22	48:30

9:57 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (FEET)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
150	30	1:50										9	11	22	22	66:30
150	35	1:40									4	10	22	21	22	81:30
150	40	1:40									7	20	21	22	22	94:30
150	45	1:40									16	21	22	22	29	112:30
150	50	1:30								3	22	22	22	21	53	145:30
150	55	1:30								11	22	21	22	26	72	176:30
150	60	1:30								17	22	22	22	34	86	205:30
limit line																
150	70	1:20							6	21	22	22	34	38	113	258:30
150	80	1:20							13	22	21	33	38	63	113	305:30
150	90	1:20							18	22	30	38	37	88	113	348:30
155	9	2:35													0	2:35
155	10	2:25													2	4:35
155	15	2:05											1	4	7	14:35
155	20	1:55										1	5	9	14	31:35
155	25	1:55										6	9	15	21	53:35
155	30	1:45									3	9	14	22	22	72:35
155	35	1:45									8	12	22	22	22	88:35
155	40	1:35								2	10	22	22	22	21	101:35
155	45	1:35								4	19	22	22	22	39	130:35
155	50	1:35								11	22	22	22	21	65	165:35
155	55	1:35								19	22	22	22	27	83	197:35
155	60	1:25							4	22	22	22	21	36	99	228:35
limit line																
155	70	1:25							14	22	22	22	37	49	113	281:35
155	80	1:25							22	22	22	36	37	76	113	330:35
155	90	1:15						5	22	22	35	37	38	100	113	374:35

9:57 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (FEET)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
160	8	2:40													0	2:40
160	10	2:30													3	5:40
160	15	2:10											2	4	8	16:40
160	20	2:00										2	7	9	16	36:40
160	25	2:00										9	9	17	22	59:40
160	30	1:50									7	9	17	22	21	78:40
160	35	1:40								2	9	16	22	22	22	95:40
160	40	1:40								5	14	22	22	22	24	111:40
160	45	1:40								9	22	22	22	22	50	149:40
160	50	1:40								19	22	22	22	21	77	185:40
limit line																
160	55	1:30							6	21	22	22	22	29	95	219:40
160	60	1:30							13	21	22	22	23	37	111	251:40
160	70	1:20						2	21	22	22	24	38	62	113	306:40
160	80	1:20						9	22	22	24	38	37	89	113	356:40
160	90	1:20						15	22	22	38	37	42	110	113	401:40
165	8	2:45													0	2:45
165	10	2:35													4	6:45
165	15	2:15											4	3	10	19:45
165	20	2:05										4	8	9	18	41:45
165	25	1:55									3	9	10	19	21	64:45
165	30	1:45								1	9	9	20	22	22	85:45
165	35	1:45								6	9	19	22	22	22	102:45
165	40	1:45								9	18	21	22	22	34	128:45
165	45	1:35							3	14	22	22	21	22	63	169:45
165	50	1:35							5	22	22	22	22	22	89	206:45

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
limit line																
165	55	1:35							14	22	22	21	22	32	107	242:45
165	60	1:35							21	22	22	22	25	46	113	273:45
165	70	1:25						11	21	22	22	27	37	77	113	332:45
165	80	1:25						19	21	22	28	37	38	102	113	382:45
170	7	2:50													0	2:50
170	10	2:30												1	4	7:50
170	15	2:10										1	4	5	9	21:50
170	20	2:00									1	5	9	9	19	45:50
170	25	2:00									6	10	9	21	22	70:50
170	30	1:50								4	10	9	22	22	22	91:50
170	35	1:50								10	9	22	22	21	22	108:50
170	40	1:40							4	9	21	22	22	21	46	147:50
170	45	1:40							7	17	22	22	22	22	74	188:50
170	50	1:40							13	22	22	22	22	23	102	228:50
limit line																
170	55	1:30						1	21	22	22	22	22	39	112	263:50
170	60	1:30						8	22	22	21	22	27	60	113	297:50
170	70	1:30						20	21	22	22	30	37	90	113	357:50
170	80	1:20					6	22	22	22	30	38	42	113	113	410:50
175	7	2:55													0	2:55
175	10	2:35												2	4	8:55
175	15	2:15										3	3	6	10	24:55
175	20	2:05									3	6	9	9	21	50:55
175	25	1:55								1	9	9	11	22	21	75:55
175	30	1:55								8	9	12	22	22	22	97:55
175	35	1:45							4	9	13	22	21	22	26	119:55

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
175	40	1:45							8	11	22	22	22	22	56	165:55
limit line																
175	45	1:35						1	10	21	22	22	22	22	86	208:55
175	50	1:35						3	18	22	22	22	22	26	112	249:55
175	55	1:35						9	21	22	22	22	22	53	113	286:55
175	60	1:35						16	22	22	22	22	29	73	113	321:55
175	70	1:25					7	21	22	22	22	32	38	104	113	383:55
175	80	1:25					15	22	22	22	34	37	57	113	113	437:55
180	7	3:00													0	3:00
180	10	2:40												4	3	10:00
180	15	2:20										4	4	7	9	27:00
180	20	2:00								1	4	6	10	10	22	56:00
180	25	2:00								4	9	9	13	22	22	82:00
180	30	1:50							2	10	9	15	21	22	22	104:00
180	35	1:50							8	9	15	22	22	22	36	137:00
180	40	1:40						3	9	14	22	22	22	22	68	185:00
limit line																
180	45	1:40						5	13	22	22	22	21	22	101	231:00
180	50	1:40						7	22	22	22	22	22	39	113	272:00
180	55	1:40						17	22	22	22	21	22	69	113	311:00
180	60	1:30					3	22	22	22	22	21	32	87	113	347:00
180	70	1:30					16	21	22	22	22	35	43	113	113	410:00
185	7	3:05													0	3:05
185	10	2:35											1	4	3	11:05
185	15	2:15									2	3	4	8	10	30:05
185	20	2:05								2	4	8	10	12	21	60:05
185	25	1:55							1	6	9	10	15	22	21	87:05

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

EPTH FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
185	30	1:55							6	9	9	18	22	21	22	110:05
185	35	1:45						2	10	9	18	22	22	22	47	155:05
185	40	1:45						6	10	18	22	21	22	22	81	205:05
init line																
185	45	1:45						9	17	21	22	22	22	23	112	251:05
185	50	1:35					2	13	22	22	22	22	22	54	112	294:05
185	55	1:35					4	21	22	22	22	22	23	83	113	335:05
185	60	1:35					12	22	21	22	22	22	34	101	113	372:05
185	70	1:25				3	22	21	22	22	23	37	58	113	113	437:05
190	6	3:10													0	3:10
190	10	2:40											2	4	3	12:10
190	15	2:20									3	4	4	9	9	32:10
190	20	2:10								4	4	9	10	13	22	65:10
190	25	2:00							2	8	10	9	17	22	22	93:10
190	30	2:00							9	10	9	20	22	22	21	116:10
190	35	1:50						6	9	10	21	22	22	21	58	172:10
190	40	1:40					1	9	10	21	22	22	21	22	94	225:10
limit line																
190	45	1:40					4	9	20	22	22	22	22	36	113	273:10
190	50	1:40					6	17	22	22	22	22	22	68	113	317:10
190	55	1:40					12	22	21	22	22	22	25	97	113	359:10
190	60	1:40					20	22	22	22	22	22	38	113	112	396:10
190	70	1:30				12	22	21	22	22	25	38	74	113	113	465:10
195	6	3:15													0	3:15
195	10	2:45											3	4	4	14:15
195	15	2:15								1	3	4	5	9	11	36:15
195	20	2:05							2	3	6	9	10	15	22	70:15

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
195	25	2:05							4	10	9	9	20	21	22	98:15
195	30	1:55						4	9	9	10	22	22	22	31	132:15
195	35	1:45					1	9	9	12	22	21	22	22	69	190:15
195	40	1:45					5	9	12	22	22	22	22	22	106	245:15
limit line																
195	45	1:45					8	11	22	22	22	21	22	51	113	295:15
195	50	1:35				1	9	21	22	22	22	22	22	83	113	340:15
195	55	1:35				2	18	22	22	22	21	22	28	111	113	384:15
195	60	1:35				7	22	22	22	21	22	23	55	112	113	422:15
200	6	3:20													0	3:20
200	10	2:40										1	3	4	4	15:20
200	15	2:20								2	4	4	6	9	12	40:20
200	20	2:10							3	4	7	9	10	17	21	74:20
200	25	2:00						2	6	9	9	10	21	22	22	104:20
200	30	2:00						7	10	9	12	22	22	22	42	149:20
200	35	1:50					4	10	9	15	21	22	22	22	81	209:20
limit line																
200	40	1:50					9	9	15	22	22	22	22	28	113	265:20
200	45	1:40				3	9	15	22	21	22	22	22	65	113	317:20
200	50	1:40				5	13	21	22	22	22	22	22	100	113	365:20
200	55	1:40				7	21	22	22	22	22	22	41	113	113	408:20
200	60	1:40				16	21	22	22	22	22	25	70	112	113	448:20
205	6	3:25													0	3:25
205	10	2:45										2	3	4	4	16:25
205	15	2:25								4	3	4	7	9	13	43:25
205	20	2:05						1	4	3	9	9	10	18	22	79:25
205	25	2:05						4	7	9	10	11	22	21	22	109:25

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

TH (SW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
05	30	1:55					2	9	9	9	15	22	22	22	52	165:25
05	35	1:55					8	9	10	17	22	22	22	22	93	228:25
mit line																
05	40	1:45				3	10	9	19	22	21	22	22	43	112	286:25
05	45	1:45				7	9	18	22	22	22	22	22	80	112	339:25
05	50	1:45				9	17	21	22	22	22	22	25	113	112	388:25
05	55	1:35			1	14	22	21	22	22	22	22	58	113	113	433:25
05	60	1:35			3	21	22	22	22	21	22	27	86	113	113	475:25
10	5	3:30													0	3:30
10	10	2:50										3	3	4	5	18:30
10	15	2:20							1	4	4	3	9	9	14	47:30
10	20	2:10						3	3	5	9	9	9	21	22	84:30
10	25	2:00					1	4	9	10	9	13	22	22	22	115:30
10	30	2:00					5	9	10	9	18	21	22	22	63	182:30
10	35	1:50				3	9	9	9	21	22	22	22	21	107	248:30
mit line																
10	40	1:50				7	9	10	22	22	22	21	22	56	113	307:30
10	45	1:40			1	10	9	22	22	22	22	21	22	96	112	362:30
10	50	1:40			4	9	21	21	22	22	22	22	41	112	113	412:30
10	55	1:40			5	18	22	22	22	21	22	22	76	113	113	459:30
10	60	1:40			11	22	21	22	22	22	22	29	101	113	113	501:30
15	5	3:35													0	3:35
15	10	2:55										4	4	3	5	19:35
15	15	2:25							3	3	4	4	9	9	16	51:35
15	20	2:15						4	4	6	9	9	10	21	22	88:35
15	25	2:05					3	5	10	9	9	16	21	22	29	127:35
15	30	1:55				1	8	9	9	9	21	22	21	22	74	199:35

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
limit line																
215	35	1:55				6	10	9	11	22	22	21	22	29	113	268:35
215	40	1:45			2	9	9	13	22	22	22	22	22	69	113	328:35
215	45	1:45			5	10	13	22	21	22	22	22	22	111	113	386:35
215	50	1:45			8	12	22	21	22	22	22	22	57	113	113	437:35
215	60	1:35		1	18	22	22	22	22	22	21	38	111	113	112	527:35
220	5	3:40													0	3:40
220	10	2:50									1	4	4	3	6	21:40
220	15	2:30							4	4	3	5	10	9	17	55:40
220	20	2:10					2	4	3	8	9	9	11	22	22	93:40
220	25	2:00				1	4	7	9	9	9	18	22	22	38	142:40
220	30	2:00				3	9	9	10	10	22	22	21	22	85	216:40
limit line																
220	35	1:50			1	9	9	9	14	22	22	22	22	40	113	286:40
220	40	1:50			6	9	9	16	22	22	22	22	22	84	113	350:40
220	45	1:50			9	10	16	22	22	22	22	22	35	113	112	408:40
220	50	1:40		3	9	16	22	21	22	22	22	22	75	112	113	462:40
220	55	1:40		4	14	22	21	22	22	22	22	22	26	107	113	112	510:40
225	5	3:45													0	3:45
225	10	2:55									2	4	4	3	7	23:45
225	15	2:25						2	3	4	4	6	9	9	19	59:45
225	20	2:15					3	4	4	9	9	9	13	22	22	98:45
225	25	2:05				2	4	9	9	9	10	19	22	22	47	156:45
225	30	2:05				7	9	9	9	13	22	22	22	21	98	235:45
limit line																
225	35	1:55			4	10	9	9	17	22	22	22	22	54	113	307:45
225	40	1:55			10	9	9	20	22	21	22	22	22	100	113	373:45
225	45	1:45		4	9	9	21	22	22	22	21	22	51	113	113	432:45

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
225	50	1:45		7	9	20	21	22	22	22	22	22	91	113	113	487:45
225	55	1:45		8	18	22	22	22	21	22	22	38	112	113	113	536:45
230	5	3:50													0	3:50
230	10	3:00									3	4	4	4	7	25:50
230	15	2:30						3	4	3	4	7	9	10	19	62:50
230	20	2:10				1	4	4	4	9	10	9	15	21	22	102:50
230	25	2:10				4	5	9	10	9	9	22	22	22	57	172:50
230	30	2:00			2	8	9	10	9	15	22	22	22	22	110	254:50
limit line																
230	35	2:00			8	9	10	9	20	22	22	21	22	68	112	326:50
230	40	1:50		4	9	10	10	22	22	22	21	22	24	113	113	395:50
230	45	1:50		8	9	12	22	21	22	22	22	22	67	113	113	456:50
230	50	1:40	1	10	11	22	21	22	22	22	22	23	107	113	113	512:50
230	55	1:40	3	9	22	22	22	22	22	22	21	56	113	112	113	562:50
235	5	3:55													0	3:55
235	10	2:55								1	3	4	4	4	8	27:55
235	15	2:25					1	3	4	4	3	9	9	9	21	66:55
235	20	2:15				3	3	4	6	9	10	9	16	22	22	107:55
235	25	2:05			2	4	6	10	9	9	11	22	22	22	68	188:55
235	30	2:05			4	10	9	9	9	18	22	22	22	30	113	271:55
limit line																
235	35	1:55		3	9	9	9	11	22	21	22	22	22	81	113	347:55
235	40	1:55		8	9	10	13	22	22	22	22	21	39	113	113	417:55
235	45	1:45	3	9	9	15	22	22	22	22	22	21	85	113	113	481:55
235	50	1:45	5	10	15	22	21	22	22	22	22	35	113	113	112	537:55
240	5	4:00													0	4:00
240	10	3:00								2	3	4	4	4	8	29:00

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
240	15	2:30						2	4	3	4	4	9	9	10	22	71:00
240	20	2:10				1	3	4	4	7	9	10	9	18	22	23	114:00
240	25	2:10				4	3	9	9	9	9	14	22	21	22	79	205:00
limit line																	
240	30	2:00			1	7	9	9	10	9	20	22	22	22	42	113	290:00
240	35	2:00			6	10	9	9	13	22	22	22	22	22	95	113	369:00
240	40	1:50		3	9	9	9	17	22	22	22	22	22	53	113	113	440:00
240	45	1:50		7	9	9	19	22	22	22	21	22	22	102	112	113	506:00
240	50	1:50		9	10	19	22	21	22	22	22	22	52	113	113	113	564:00
245	5	3:55														1	5:05
245	10	3:05									3	3	4	4	4	9	31:05
245	15	2:35						3	4	4	3	5	9	10	11	22	75:05
245	20	2:15				2	4	3	4	9	9	9	10	20	22	31	127:05
245	25	2:05			1	4	5	9	9	9	10	15	22	22	22	90	222:05
limit line																	
245	30	2:05			3	8	10	9	9	11	21	22	22	22	55	113	309:05
245	35	1:55		1	9	9	10	9	16	22	22	22	21	22	111	113	391:05
245	40	1:55		7	9	9	9	21	21	22	22	22	22	69	113	113	463:05
245	45	1:45	1	10	9	10	22	21	22	22	22	22	28	111	113	113	530:05
245	50	1:45	4	9	11	22	21	22	22	22	22	22	70	113	113	113	590:05
250	5	4:00														1	5:10
250	10	3:10									4	4	3	4	5	9	33:10
250	15	2:30					1	4	3	4	4	6	9	9	14	21	79:10
250	20	2:20				3	4	4	5	9	9	9	10	21	22	40	140:10
250	25	2:10			3	4	6	9	9	10	9	18	21	22	22	102	239:10
limit line																	
250	30	2:00		1	5	9	9	9	10	13	21	22	22	22	68	113	328:10
250	35	2:00		5	9	9	9	10	19	22	21	22	22	34	113	113	412:10

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.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
250	40	1:50		1	9	10	9	11	22	22	21	22	22	22	86	113	113	487:10
250	45	1:50		5	10	9	13	22	22	22	22	22	21	44	113	113	113	555:10
250	50	1:50		8	9	15	22	21	22	22	22	22	22	89	113	113	112	616:10
255	5	4:05															2	6:15
255	10	3:05									1	4	4	3	4	6	9	35:15
255	15	2:35						2	4	4	3	4	7	9	10	14	22	83:15
255	20	2:15				1	4	4	3	6	10	9	9	11	22	22	49	154:15
255	25	2:05			1	4	3	8	9	10	9	9	20	22	22	21	113	255:15
limit line																		
255	30	2:05			3	6	9	10	9	9	16	22	21	22	22	82	113	348:15
255	35	2:05			8	10	9	9	10	21	22	22	22	22	47	113	113	432:15
255	40	1:55		5	9	9	10	14	22	22	22	21	22	22	103	113	112	510:15
255	45	1:55		9	9	10	17	22	22	21	22	22	22	61	113	112	113	579:15
255	50	1:45	3	9	9	10	22	21	22	22	22	22	22	27	102	113	113	113	643:15
260	5	4:10															2	6:20
260	10	3:10									2	4	4	3	4	6	10	37:20
260	15	2:40						3	4	4	4	3	8	10	9	16	22	87:20
260	20	2:20				3	3	4	4	7	10	9	9	13	22	22	58	168:20
260	25	2:10			2	4	4	9	10	9	9	9	22	22	22	32	113	271:20
limit line																		
260	30	2:00		1	3	9	9	9	9	10	18	22	21	22	22	95	113	367:20
260	35	2:00		3	9	9	10	9	12	22	22	22	22	21	63	113	113	454:20
260	40	2:00		9	9	9	10	17	22	22	22	22	21	31	110	112	113	533:20
260	45	1:50	4	9	9	10	20	22	22	22	22	22	22	78	113	113	112	604:20
265	5	4:15															3	7:25
265	10	3:15									3	4	4	3	4	7	9	38:25
265	15	2:35					1	4	4	3	4	4	9	9	9	19	22	92:25

9:57 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (FEET)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
265	20	2:15				1	3	4	4	3	9	10	9	9	15	22	22	68	183:25
265	25	2:15				4	4	5	10	9	9	9	12	22	22	21	45	113	289:25
limit line																			
265	30	2:05			2	5	9	9	10	9	9	21	22	22	21	22	109	113	387:25
265	35	2:05			6	10	9	9	9	16	22	22	21	22	22	78	113	113	476:25
265	40	1:55		3	10	9	9	9	21	22	22	22	22	22	42	113	113	113	556:25
265	45	1:55		8	9	9	12	22	22	22	22	21	22	22	97	112	113	113	630:25
270	5	4:20																3	7:30
270	10	3:10									1	3	4	4	3	4	8	9	40:30
270	15	2:40						2	4	4	4	3	5	9	9	10	20	21	95:30
270	20	2:20				2	4	3	4	5	9	9	10	9	17	22	22	77	197:30
270	25	2:10			2	4	3	8	9	9	9	10	13	22	22	22	56	113	306:30
limit line																			
270	30	2:10			4	7	9	9	9	10	10	22	22	22	21	32	113	113	407:30
270	35	2:00		1	9	9	10	9	9	18	22	22	22	22	22	93	113	112	497:30
270	40	2:00		7	10	9	9	12	21	22	22	22	22	22	60	113	112	113	580:30
270	45	1:50	3	9	9	9	16	22	21	22	22	22	22	32	104	113	112	113	655:30
275	5	4:25																4	8:35
275	10	3:15									2	3	4	4	4	3	9	9	42:35
275	15	2:45						4	4	3	4	4	5	10	9	9	22	22	100:35
275	20	2:25				3	4	4	4	6	9	9	10	9	19	22	22	87	212:35
limit line																			
275	25	2:15			4	3	4	9	9	9	10	9	16	22	21	22	69	113	324:35
275	30	2:05		2	3	9	9	10	9	9	13	22	22	22	21	45	113	113	426:35
275	35	2:05		5	9	9	9	10	9	21	22	22	22	21	27	104	113	113	520:35
275	40	1:55	2	9	9	10	9	15	22	21	22	22	22	22	77	113	113	113	605:35
275	45	1:55	7	9	9	9	19	22	22	22	22	22	21	44	110	113	113	113	681:35
280	5	4:20															1	4	9:40

9:57 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (FEET)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
280	10	3:20										3	3	4	4	4	3	9	10	44:40
280	15	2:40						1	4	4	4	3	4	7	9	9	12	21	22	104:40
280	20	2:20				1	4	4	3	4	8	9	9	9	10	21	22	22	98	226:40
limit line																				
280	25	2:10			1	4	4	5	9	9	10	9	9	18	22	22	22	80	113	341:40
280	30	2:10			3	5	10	9	9	9	10	15	22	22	22	22	21	59	113	113 446:40
280	35	2:00		1	7	10	9	9	9	12	22	22	21	22	22	37	109	113	113	542:40
280	40	2:00		6	9	9	9	10	18	22	22	21	22	22	22	95	113	112	113	629:40
280	45	1:50	1	9	10	9	10	22	22	22	21	22	22	22	59	113	113	113	113	707:40
285	5	4:25																1	4	9:45
285	10	3:25										4	3	4	4	4	4	9	11	47:45
285	15	2:45						3	3	4	4	4	3	8	9	10	13	22	23	110:45
285	20	2:25				3	4	3	4	4	9	9	9	9	12	22	22	21	108	243:45
limit line																				
285	25	2:15			3	4	3	7	9	10	9	9	9	21	22	22	21	94	112	359:45
285	30	2:05		1	4	7	9	9	10	9	9	18	22	22	22	22	73	113	113	467:45
285	35	2:05		3	9	9	10	9	9	14	22	22	22	22	22	48	113	113	113	564:45
285	40	2:05		10	9	9	9	10	21	22	22	22	21	22	32	101	113	113	113	653:45
285	45	1:55	5	9	10	9	14	21	22	22	22	22	22	22	78	113	113	112	113	733:45
290	5	4:30																2	4	10:50
290	10	3:20									1	4	3	4	4	4	5	9	12	50:50
290	15	2:50						4	4	3	4	4	4	9	9	9	15	22	31	122:50
290	20	2:20			1	3	4	4	3	5	9	10	9	9	14	22	22	27	112	258:50
limit line																				
290	25	2:10		1	4	3	4	8	10	9	9	9	11	22	22	21	26	102	113	378:50
290	30	2:10		3	4	8	10	9	9	9	10	20	22	22	22	22	87	113	113	487:50
290	35	2:10		6	10	9	9	9	10	17	22	22	22	21	22	66	112	113	113	587:50
290	40	2:00	4	9	10	9	9	12	22	22	22	22	21	22	44	107	113	112	113	677:50

9:57 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (FEET)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TM (M)	TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCNT TIME (M:S)
290	45	2:00			9	9	10	9	17	22	22	22	22	21	22	27	92	113	113	112	113	759:50
295	5	4:35																		3	3	10:55
295	10	3:25											2	4	3	4	4	4	5	9	14	53:55
295	15	2:45							2	3	4	4	4	3	5	9	9	9	18	22	38	134:55
295	20	2:25					2	4	3	4	4	6	9	9	10	9	16	22	22	36	113	273:55
limit line																						
295	25	2:15				2	4	4	4	10	9	9	9	10	12	22	22	22	34	106	113	396:55
295	30	2:05			1	4	5	9	9	9	10	9	10	22	22	22	22	27	97	113	113	508:55
295	35	2:05			2	8	9	10	9	9	9	21	22	21	22	22	22	81	113	113	113	610:55
295	40	2:05			8	9	9	10	9	15	22	22	22	22	22	21	56	113	112	113	113	702:55
300	5	4:40																		3	4	12:00
300	10	3:30											3	4	3	4	4	4	6	9	15	57:00
300	15	2:50							3	4	3	4	4	4	5	9	9	10	19	22	45	146:00
300	20	2:30					4	3	4	4	3	8	9	9	10	9	18	22	22	47	112	289:00
limit line																						
300	25	2:20				4	4	3	6	10	9	9	9	10	15	22	21	22	44	109	113	415:00
300	30	2:10			2	4	7	9	10	9	9	9	13	22	22	22	22	37	101	113	113	529:00
300	35	2:10			5	9	9	9	10	9	10	22	22	22	22	22	26	93	113	112	113	633:00
300	40	2:00		3	9	9	9	10	9	18	22	22	22	22	22	22	73	113	112	113	113	728:00
limit line																						
310	6	4:30																3	4	4	3	19:10
310	10	3:30										1	4	4	3	4	4	4	7	10	17	63:10
310	15	2:50						2	4	3	4	4	3	4	8	9	9	12	22	21	60	170:10
310	20	2:30				3	3	4	4	4	4	9	10	9	9	11	22	22	21	67	113	320:10
310	25	2:20			3	4	4	4	9	9	9	10	9	9	20	22	22	22	65	113	113	452:10
310	30	2:10		2	4	5	9	9	9	10	9	9	18	22	22	22	22	57	111	113	113	571:10
310	35	2:10		3	9	9	9	10	9	9	17	21	22	22	22	22	48	103	113	113	113	679:10
310	40	2:00	1	9	9	10	9	9	13	22	21	22	22	22	22	36	94	112	113	113	113	777:10

9:57 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (FEET)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN)																			TOTAL ASCNT TIME (M:S)
			190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	
limit line																						
320	6	4:30															1	4	3	4	4	21:20
320	10	3:40										3	4	4	3	4	4	4	9	9	20	69:20
320	15	2:50					1	3	4	4	4	3	4	4	9	10	9	16	21	22	75	194:20
320	20	2:30			2	4	3	4	4	4	7	9	9	10	9	16	22	21	25	88	112	354:20
320	25	2:20		3	4	3	4	7	9	10	9	9	9	13	22	22	22	28	87	113	113	492:20
320	30	2:10	1	4	4	9	9	9	9	10	9	11	21	22	22	22	26	82	113	112	113	613:20
320	35	2:10	3	7	9	10	9	9	9	10	22	22	21	22	22	22	73	113	113	113	112	726:20
320	40	2:10	9	9	9	9	10	9	19	22	22	21	22	22	22	60	107	113	113	113	112	828:20

MK 15/16 0.7 ATA PO_2
in He Decompression Tables

Depth in Meters of Sea Water (MSW)
Stops in 3 MSW Increments

Ascent Rate 20 MPM (1 meter every 3 sec)*

* Royal Navy Ascent Rates.

NOTE: Time/Date reflects only when tables actually printed, not version.

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(HVAL21- HELIUM)

TISSUE HALF-TIMES

DEPTH	5 MIN 1.00 SDR	10 MIN .83 SDR	20 MIN .71 SDR	40 MIN .83 SDR	80 MIN .83 SDR	120 MIN .83 SDR
3 MSW	115.000	96.000	77.000	65.000	55.000	48.000
6 MSW	125.827	106.827	87.827	75.827	65.827	58.827
9 MSW	136.654	117.654	98.654	86.654	76.654	69.654
12 MSW	147.480	128.480	109.480	97.480	87.480	80.480
15 MSW	158.307	139.307	120.307	108.307	98.307	91.307
18 MSW	169.134	150.134	131.134	119.134	109.134	102.134
21 MSW	179.961	160.961	141.961	129.961	119.961	112.961
24 MSW	190.787	171.787	152.787	140.787	130.787	123.787
27 MSW	201.614	182.614	163.614	151.614	141.614	134.614
30 MSW	212.441	193.441	174.441	162.441	152.441	145.441
33 MSW	223.268	204.268	185.268	173.268	163.268	156.268
36 MSW	234.095	215.095	196.095	184.095	174.095	167.095
39 MSW	244.921	225.921	206.921	194.921	184.921	177.921
42 MSW	255.748	236.748	217.748	205.748	195.748	188.748
45 MSW	266.575	247.575	228.575	216.575	206.575	199.575
48 MSW	277.402	258.402	239.402	227.402	217.402	210.402
51 MSW	288.228	269.228	250.228	238.228	228.228	221.228
54 MSW	299.055	280.055	261.055	249.055	239.055	232.055
57 MSW	309.882	290.882	271.882	259.882	249.882	242.882
60 MSW	320.709	301.709	282.709	270.709	260.709	253.709
63 MSW	331.536	312.536	293.536	281.536	271.536	264.536
66 MSW	342.362	323.362	304.362	292.362	282.362	275.362
69 MSW	353.189	334.189	315.189	303.189	293.189	286.189
72 MSW	364.016	345.016	326.016	314.016	304.016	297.016
75 MSW	374.843	355.843	336.843	324.843	314.843	307.843
78 MSW	385.669	366.669	347.669	335.669	325.669	318.669
81 MSW	396.496	377.496	358.496	346.496	336.496	329.496
84 MSW	407.323	388.323	369.323	357.323	347.323	340.323
87 MSW	418.150	399.150	380.150	368.150	358.150	351.150
90 MSW	428.977	409.977	390.977	378.977	368.977	361.977

BLOOD PARAMETERS

(PRESSURE IN FSW; 33 FSW=1 ATA)

PACO2	PH2O	PVCO2	PVO2	AMBAO2	P80VP
1.50	0.00	2.30	2.00	0.00	0.000

10:34 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (METERS)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 20 MPM; ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 39	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCNT TIME (M:S)
12	370	0:36													0	0:36
limit line																
12	380	0:36													0	0:36
12	390	0:36													0	0:36
15	214	0:45													0	0:45
15	220	0:36													3	3:45
15	230	0:36													9	9:45
15	240	0:36													14	14:45
15	250	0:36													19	19:45
limit line																
15	260	0:36													23	23:45
15	270	0:36													27	27:45
15	280	0:36													31	31:45
15	290	0:36													35	35:45
15	300	0:36													39	39:45
15	310	0:36													42	42:45
15	320	0:36													45	45:45
15	330	0:36													48	48:45
15	340	0:36													51	51:45
15	350	0:36													54	54:45
15	360	0:36													56	56:45
15	370	0:36													59	59:45
15	380	0:36													61	61:45
15	390	0:36													63	63:45
18	137	0:54													0	0:54
18	140	0:45													3	3:54
18	150	0:45													14	14:54

34 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (METERS)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 20 MPM; ASCENT 20 MPM

PTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 39	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCNT TIME (M:S)
18	160	0:45													25	25:54
18	170	0:45													34	34:54
mit line																
18	180	0:45													44	44:54
18	190	0:45													52	52:54
18	200	0:45													61	61:54
18	210	0:45													69	69:54
18	220	0:45													76	76:54
18	230	0:45													83	83:54
18	240	0:45													89	89:54
18	250	0:45													96	96:54
18	260	0:45													101	101:54
18	270	0:45													107	107:54
18	280	0:36												1	111	112:54
18	290	0:36												6	111	117:54
18	300	0:36												11	111	122:54
18	310	0:36												15	111	126:54
18	320	0:36												19	111	130:54
18	330	0:36												23	111	134:54
18	340	0:36												27	111	138:54
18	350	0:36												30	111	141:54
18	360	0:36												33	112	145:54
18	370	0:36												37	111	148:54
18	380	0:36												39	112	151:54
18	390	0:36												42	111	153:54
21	85	1:03													0	1:03

10:34 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (METERS)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 20 MPM; ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 39	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCNT TIME (M:S)
21	90	0:54													4	5:03
21	100	0:54													10	11:03
21	110	0:54													15	16:03
21	120	0:54													29	30:03
21	130	0:54													45	46:03
21	140	0:54													59	60:03
limit line																
21	150	0:54													73	74:03
21	160	0:54													85	86:03
21	170	0:54													97	98:03
21	180	0:45												2	107	110:03
21	190	0:45												9	111	121:03
21	200	0:45												19	111	131:03
21	210	0:45												28	111	140:03
21	220	0:45												37	111	149:03
21	230	0:45												46	111	158:03
21	240	0:45												54	111	166:03
21	250	0:45												62	111	174:03
21	260	0:45												69	111	181:03
21	270	0:45												75	112	188:03
24	54	1:12													0	1:12
24	60	1:03													4	5:12
24	70	1:03													11	12:12
24	80	1:03													21	22:12
24	90	1:03													30	31:12
24	100	1:03													40	41:12

: AM TUE., 16 APR., 1985 TBLP7 HVAL21 (METERS)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 20 MPM; ASCENT 20 MPM

H BTM TM TO) TIM FIRST (M) STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 39	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCNT TIME (M:S)
110 0:54												6	55	62:12
120 0:54												11	69	81:12
t line														
130 0:54												16	82	99:12
140 0:54												19	96	116:12
150 0:54												28	103	132:12
160 0:54												38	108	147:12
170 0:54												49	111	161:12
180 0:54												63	111	175:12
190 0:54												76	111	188:12
38 1:21													0	1:21
40 1:12													3	4:21
50 1:12													13	14:21
60 1:12													21	22:21
70 1:03												5	30	36:21
80 1:03												10	36	47:21
90 1:03												19	41	61:21
100 1:03												28	56	85:21
110 1:03												35	73	109:21
120 0:54											4	37	89	131:21
it line														
130 0:54											9	43	99	152:21
140 0:54											13	52	106	172:21
150 0:54											16	62	111	190:21
160 0:54											19	77	111	208:21
30 1:30													0	1:30
35 1:21													9	10:30

10:34 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (METERS)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 20 MPM; ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 39	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCNT TIME (M:S)
30	40	1:21													17	18:30
30	50	1:12												8	21	30:30
30	60	1:12												16	26	43:30
30	70	1:03											1	22	35	59:30
30	80	1:03											5	30	37	73:30
30	90	1:03											9	37	55	102:30
30	100	1:03											18	37	74	130:30
limit line																
30	110	1:03											26	37	92	156:30
30	120	1:03											33	47	100	181:30
30	130	0:54										2	37	58	107	205:30
30	140	0:54										7	36	72	111	227:30
33	23	1:39													0	1:39
33	25	1:30													2	3:39
33	30	1:30													12	13:39
33	35	1:21												1	22	24:39
33	40	1:21												10	21	32:39
33	50	1:12											2	22	21	46:39
33	60	1:12											12	21	31	65:39
33	70	1:12											19	25	37	82:39
33	80	1:03										2	22	35	51	111:39
33	90	1:03										6	29	37	71	144:39
33	100	1:03										9	37	37	91	175:39
limit line																
33	110	1:03										18	37	48	100	204:39
33	120	1:03										25	37	62	106	231:39
33	130	1:03										32	37	77	111	258:39

10:34 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (METERS)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 20 MPM; ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 39	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCNT TIME (M:S)
33	140	1:03										37	48	86	111	283:39
36	18	1:48													0	1:48
36	25	1:39													11	12:48
36	30	1:30												4	21	26:48
36	35	1:30												15	21	37:48
36	40	1:21											3	21	22	47:48
36	50	1:21											18	22	22	63:48
36	60	1:12										7	22	21	35	86:48
36	70	1:12										15	21	32	47	116:48
36	80	1:12										20	28	36	67	152:48
limit line																
36	90	1:03									3	22	37	36	89	188:48
36	100	1:03									5	31	37	47	100	221:48
36	110	1:03									9	37	37	61	108	253:48
36	120	1:03									18	37	38	80	111	285:48
39	14	1:57													0	1:57
39	20	1:48													8	9:57
39	25	1:39												6	16	23:57
39	30	1:30											2	13	22	38:57
39	35	1:30											7	21	22	51:57
39	40	1:30											17	22	21	61:57
39	50	1:21										12	22	21	26	82:57
39	60	1:12									3	21	22	24	41	112:57
39	70	1:12									11	22	21	37	65	157:57
limit line																
39	80	1:12									17	22	33	37	87	197:57
39	90	1:12									21	30	37	42	103	234:57

10:34 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (METERS)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 20 MPM; ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 39	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCNT TIME (M:S)
39	100	1:03								3	24	37	37	58	110	270:57
39	110	1:03								5	33	37	37	81	111	305:57
39	120	1:03								10	37	37	52	88	112	337:57
42	11	2:06													0	2:06
42	15	1:57													4	6:06
42	20	1:48												5	9	16:06
42	25	1:39											4	9	20	35:06
42	30	1:30										1	9	18	21	51:06
42	35	1:30										4	16	21	22	65:06
42	40	1:30										10	22	21	22	77:06
42	50	1:21									7	21	22	21	29	102:06
42	60	1:21									20	21	22	28	59	152:06
42	70	1:12								7	22	21	28	37	85	202:06
limit line																
42	80	1:12								14	21	26	36	37	109	245:06
42	90	1:12								18	22	37	37	57	111	284:06
42	100	1:12								22	32	37	37	81	111	322:06
45	10	2:15													0	2:15
45	15	1:57												3	5	10:15
45	20	1:48											2	9	12	25:15
45	25	1:39										1	10	11	22	46:15
45	30	1:39										8	10	22	21	63:15
45	35	1:30									3	9	21	22	21	78:15
45	40	1:30									6	19	21	22	21	91:15
45	45	1:30									14	21	22	21	24	104:15
45	50	1:21								1	22	21	22	21	47	136:15

10:34 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (METERS)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 20 MPM; ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 39	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCNT TIME (M:S)
45	60	1:21								15	22	21	22	32	81	195:15
limit line																
45	70	1:12							3	22	22	21	33	37	106	246:15
45	80	1:12							11	21	22	31	37	58	111	293:15
45	90	1:12							15	22	30	37	36	83	111	336:15
48	8	2:24													0	2:24
48	10	2:15													2	4:24
48	15	1:57											2	4	7	15:24
48	20	1:48										2	6	9	15	34:24
48	25	1:48										8	9	16	22	57:24
48	30	1:39									6	9	16	21	22	76:24
48	35	1:30								1	9	15	22	21	22	92:24
48	40	1:30								4	13	22	21	22	21	105:24
48	45	1:30								7	22	21	22	21	44	139:24
48	50	1:30								17	22	21	22	21	70	175:24
limit line																
48	55	1:21							4	21	22	21	22	28	89	209:24
48	60	1:21							11	21	22	21	22	37	104	240:24
48	70	1:21							21	22	21	23	37	56	111	293:24
48	80	1:12						7	22	21	23	37	37	83	111	343:24
48	90	1:12						13	21	22	37	37	39	106	111	388:24
51	8	2:33													0	2:33
51	10	2:15												1	4	7:33
51	15	1:57										1	4	4	9	20:33
51	20	1:48									1	4	9	9	18	43:33
51	25	1:48									6	9	9	20	21	67:33
51	30	1:39								3	10	9	21	21	22	88:33

10:34 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (METERS)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 20 MPM; ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 39	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCNT TIME (M:S)
51	35	1:39								9	9	21	21	22	21	105:33
51	40	1:30							3	9	20	21	22	21	40	138:33
51	45	1:30							6	16	22	21	22	22	67	178:33
51	50	1:30							11	22	21	22	21	23	94	216:33
limit line																
51	55	1:30							20	22	21	22	21	33	111	252:33
51	60	1:21						6	21	22	21	22	26	53	111	284:33
51	70	1:21						17	22	21	22	29	36	84	111	344:33
51	80	1:12					4	21	22	22	29	37	37	110	111	395:33
54	7	2:42													0	2:42
54	10	2:24												3	4	9:42
54	15	2:06										4	3	7	9	25:42
54	20	1:48								1	3	7	9	9	22	53:42
54	25	1:48								3	9	9	12	22	21	78:42
54	30	1:39							1	10	9	14	21	22	21	100:42
54	35	1:39							7	9	14	22	21	22	30	127:42
54	40	1:30						2	9	13	22	22	21	22	61	174:42
limit line																
54	45	1:30						4	12	22	21	22	21	22	93	219:42
54	50	1:30						6	21	22	21	22	21	33	111	259:42
54	55	1:30						15	21	22	22	21	22	61	111	297:42
54	60	1:21					1	22	21	22	21	22	30	80	111	332:42
54	70	1:21					13	22	22	21	22	34	37	110	112	395:42
57	6	2:51													0	2:51
57	10	2:24											2	4	3	11:51
57	15	2:06									3	4	3	9	9	30:51
57	20	1:57								3	4	10	9	12	22	62:51

10:34 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (METERS)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 20 MPM; ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 39	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCNT TIME (M:S)
57	25	1:48							2	8	9	9	16	22	21	89:51
57	30	1:48							8	10	9	19	21	22	21	112:51
57	35	1:39						5	9	9	21	21	22	21	51	161:51
57	40	1:39						9	9	21	21	22	21	22	85	212:51
limit line																
57	45	1:30					3	9	19	22	21	22	21	30	111	260:51
57	50	1:30					5	16	22	21	22	22	21	61	111	303:51
57	55	1:30					10	21	22	21	22	21	25	89	111	344:51
57	60	1:30					18	22	21	22	21	22	35	107	111	381:51
57	70	1:21				10	21	22	21	22	24	37	67	111	111	448:51
60	6	3:00													0	3:00
60	10	2:33											4	4	3	14:00
60	15	2:06								2	4	3	6	9	11	38:00
60	20	1:57							3	4	6	9	10	16	21	72:00
60	25	1:48						1	6	9	9	9	21	21	22	101:00
60	30	1:48						6	10	9	11	22	21	22	35	139:00
60	35	1:39					3	9	10	14	21	22	21	22	74	199:00
60	40	1:39					8	9	14	22	22	21	22	22	111	254:00
limit line																
60	45	1:30				2	9	14	21	22	21	22	21	58	111	304:00
60	50	1:30				4	12	21	22	21	22	21	22	92	111	351:00
60	55	1:30				5	21	22	21	22	21	22	34	111	111	393:00
60	60	1:30				14	21	22	21	22	21	24	63	111	111	433:00
63	5	3:09													0	3:09
63	10	2:33										3	3	4	4	17:09
63	15	2:06							1	4	3	4	8	9	13	45:09
63	20	1:57						2	4	4	9	9	9	20	21	81:09

10:34 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (METERS)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 20 MPM; ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 39	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCNT TIME (M:S)
63	25	1:48					1	4	8	10	9	12	22	21	22	112:09
63	30	1:48					4	9	10	9	17	21	22	21	57	173:09
63	35	1:39				2	9	9	9	20	21	22	21	22	98	236:09
limit line																
63	40	1:39				6	9	9	22	21	22	21	22	48	111	294:09
63	45	1:39				10	9	21	21	22	21	22	21	87	111	348:09
63	50	1:30			3	9	19	22	22	21	22	21	33	112	111	398:09
63	55	1:30			4	17	22	21	22	21	22	21	68	111	111	443:09
63	60	1:30			9	21	22	21	22	22	21	28	93	111	111	484:09
66	5	3:18													0	3:18
66	10	2:33									1	4	3	4	6	21:18
66	15	2:15							4	3	4	5	9	9	16	53:18
66	20	1:57					1	4	4	7	9	9	10	22	22	91:18
66	25	1:48				1	3	7	9	9	9	17	22	21	32	133:18
66	30	1:48				2	9	9	10	9	22	21	22	21	77	205:18
limit line																
66	35	1:48				9	9	9	14	21	22	21	22	33	111	274:18
66	40	1:39			5	9	9	15	22	22	21	22	21	77	111	337:18
66	45	1:39			8	9	16	22	21	22	21	22	27	111	111	393:18
66	50	1:30		2	9	15	21	22	21	22	21	22	66	111	111	446:18
66	55	1:30		3	13	21	22	21	22	21	22	22	101	111	111	493:18
66	60	1:30		5	21	21	22	21	22	21	22	45	111	111	111	536:18
69	5	3:27													0	3:27
69	10	2:42									3	4	4	3	7	24:27
69	15	2:15						3	3	4	4	7	9	9	18	60:27
69	20	1:57				1	4	3	5	9	9	9	14	21	22	100:27
69	25	1:57				4	4	9	10	9	9	21	21	22	51	163:27

10:34 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (METERS)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 20 MPM; ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 39	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCNT TIME (M:S)
69	30	1:48			1	8	9	9	10	14	22	21	22	21	101	241:27
limit line																
69	35	1:48			7	9	10	9	19	21	22	21	22	59	111	313:27
69	40	1:39		3	9	10	9	22	21	22	21	22	21	106	111	380:27
69	45	1:39		7	9	11	21	22	21	22	22	21	58	111	111	439:27
69	50	1:39		9	11	21	22	21	22	22	21	22	98	111	111	494:27
69	55	1:30	2	9	21	22	21	22	21	22	21	47	111	111	111	544:27
72	5	3:36													0	3:36
72	10	2:42								2	3	4	4	4	8	28:36
72	15	2:15					2	3	4	4	3	9	9	10	21	68:36
72	20	2:06				4	4	3	7	9	10	9	17	21	22	109:36
72	25	1:57			3	4	8	9	9	9	13	21	22	21	72	194:36
72	30	1:48		1	6	9	9	9	10	19	22	21	22	35	111	277:36
limit line																
72	35	1:48		6	9	9	9	12	22	22	21	22	21	88	111	355:36
72	40	1:39	2	9	9	9	16	22	21	22	21	22	45	111	112	424:36
72	45	1:39	6	9	9	18	21	22	21	22	22	21	92	111	111	488:36
72	50	1:39	8	9	19	21	22	21	22	21	22	43	111	111	112	545:36
75	4	3:45													0	3:45
75	5	3:36													1	4:45
75	10	2:51								4	4	3	4	4	9	31:45
75	15	2:15				1	3	4	4	3	6	9	9	13	21	76:45
75	20	2:06			3	4	4	4	9	9	9	9	21	22	34	131:45
75	25	1:57		3	3	6	9	9	9	10	17	21	22	21	93	226:45
limit line																
75	30	1:48	1	4	9	9	9	9	13	21	22	21	22	60	111	314:45
75	35	1:48	4	9	9	9	9	19	21	22	21	22	25	112	111	396:45
75	40	1:48	9	10	9	10	22	21	22	21	22	21	77	111	111	469:45

10:34 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (METERS)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 20 MPM; ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 48	45	42	39	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCNT TIME (M:S)
75	45	1:39			4	9	10	12	22	21	22	21	22	22	34	111	111	111	535:45
75	50	1:39			7	9	14	21	22	21	22	21	22	22	79	111	111	111	596:45
78	4	3:54																0	3:54
78	5	3:45																3	6:54
78	10	2:51										2	4	4	3	4	6	9	35:54
78	15	2:24							3	4	4	3	4	8	9	9	15	22	84:54
78	20	2:06					2	4	4	4	7	9	9	9	12	22	21	53	159:54
78	25	1:57				2	4	3	10	9	9	9	9	21	22	21	26	111	259:54
limit line																			
78	30	1:57				4	8	9	9	9	9	18	21	22	21	22	86	111	352:54
78	35	1:48			2	9	9	9	9	12	22	21	22	21	22	53	111	111	436:54
78	40	1:48			8	9	9	9	17	22	21	22	21	22	24	106	111	111	515:54
78	45	1:39		3	9	9	9	20	22	21	22	21	22	22	68	111	111	111	584:54
78	50	1:39		6	9	9	22	21	22	21	22	21	22	33	104	111	111	111	648:54
81	5	3:54																4	8:03
81	10	2:51									1	3	4	4	4	3	7	10	40:03
81	15	2:24						2	4	4	3	4	5	9	9	9	19	21	93:03
81	20	2:06				2	3	4	4	4	9	10	9	9	16	22	21	70	187:03
81	25	1:57			2	3	4	7	9	9	9	9	14	21	22	21	49	111	294:03
limit line																			
81	30	1:57			3	7	9	9	9	9	10	22	21	22	21	25	109	111	391:03
81	35	1:48		1	8	9	10	9	9	17	22	22	21	22	21	85	111	111	482:03
81	40	1:48		6	9	10	9	11	21	22	21	22	21	22	51	111	111	111	562:03
81	45	1:39	2	9	9	9	15	21	22	21	22	21	22	26	99	111	112	111	636:03
84	5	3:54															1	4	9:12
84	10	3:00									3	4	3	4	4	3	9	9	43:12
84	15	2:24					1	4	4	3	4	4	6	9	10	10	21	22	102:12

AM TUE., 16 APR., 1985 TBLP7 HVAL21 (METERS)

70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 20 MPM; ASCENT 20 MPM

BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 54	51	48	45	42	39	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCNT TIME (M:S)
20	2:06					1	4	3	4	4	7	9	9	9	10	20	22	21	89	216:12
line																				
25	1:57				1	4	3	5	9	9	10	9	9	17	22	21	22	72	111	328:12
30	1:57				3	5	9	9	9	9	9	15	22	21	22	21	51	111	111	431:12
35	1:57				8	9	9	9	9	11	22	21	22	21	22	31	105	111	111	525:12
40	1:48			5	9	9	9	9	18	21	22	21	22	21	22	84	112	111	111	610:12
45	1:48			9	10	9	9	22	21	22	21	22	21	22	49	111	111	112	111	686:12
5	4:03																	2	4	10:21
10	3:00										1	4	4	3	4	4	4	9	12	49:21
15	2:33							4	4	3	4	4	3	9	9	9	14	22	26	115:21
20	2:15					4	4	3	4	5	9	9	9	9	13	21	22	23	108	247:21
t line																				
25	1:57			1	3	4	4	8	9	9	9	9	10	21	22	22	21	97	111	364:21
30	1:57			2	4	9	9	9	9	9	9	20	22	21	22	21	79	111	111	471:21
35	1:57			6	9	9	9	9	9	17	22	21	22	21	22	56	111	111	111	569:21
40	1:48		3	9	10	9	9	11	22	21	22	22	21	22	36	103	111	111	111	657:21
45	1:48		8	9	9	9	17	22	21	22	21	22	21	22	86	111	111	111	111	737:21
5	4:12																	4	3	11:30
10	3:09										3	4	4	3	4	4	6	9	13	54:30
15	2:33						3	4	3	4	4	3	6	9	9	9	19	21	41	139:30
20	2:15				3	4	4	3	4	7	9	10	9	9	17	21	22	40	111	277:30
t line																				
25	2:06			4	3	4	6	9	9	9	9	10	14	21	22	21	38	106	111	400:30
30	1:57		2	4	6	9	10	9	9	9	13	21	22	21	22	31	98	111	111	512:30
35	1:57		4	9	9	9	9	10	10	21	22	21	22	21	22	87	112	111	111	614:30
40	1:48	2	9	9	9	9	9	19	21	22	21	22	21	22	63	111	112	111	111	707:30
5	4:12																1	4	3	12:39
10	3:09									2	3	4	4	3	4	4	7	9	17	61:39

10:34 AM TUE., 16 APR., 1985 TBLP7 HVAL21 (METERS)

.70 ATA FIXED PO2 IN HELIUM RATES: DESCENT 20 MPM; ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN)																				TOTAL ASCNT TIME (M:S)
			60	57	54	51	48	45	42	39	36	33	30	27	24	21	18	15	12	9	6	3	
93	15	2:33							2	4	3	4	4	3	4	7	10	9	10	22	21	55	162:39
93	20	2:15					3	3	4	4	3	5	9	9	9	9	10	22	21	22	60	111	308:39
limit line																							
93	25	2:06				3	4	4	3	9	9	10	9	9	9	19	22	21	22	58	111	111	437:39
93	30	1:57			2	3	5	9	9	10	9	9	9	17	22	22	21	22	51	107	111	111	553:39
93	35	1:57			3	8	9	9	10	9	9	16	21	22	21	22	21	42	100	111	111	111	659:39
93	40	1:57			9	10	9	9	9	12	22	21	22	21	22	21	30	90	111	111	111	111	755:39
limit line																							
96	5	4:21																		2	4	4	14:48
96	10	3:18											4	3	4	4	3	4	4	9	9	19	67:48
96	15	2:33						1	4	3	4	4	3	4	4	9	9	9	15	22	21	70	186:48
96	20	2:15				2	4	3	4	4	3	8	9	9	9	9	15	21	22	23	82	111	342:48
96	25	2:06			3	3	4	4	7	9	9	9	9	9	12	22	21	22	26	81	111	111	476:48
96	30	1:57		1	4	4	8	9	9	9	10	9	10	22	21	22	21	23	76	111	111	111	595:48
96	35	1:57		2	7	10	9	9	9	9	9	22	21	22	21	22	21	64	111	111	111	111	705:48
96	40	1:57		8	9	9	9	9	9	19	22	21	22	21	22	21	53	103	111	111	111	111	805:48
limit line																							
99	5	4:30																		3	4	4	15:57
99	10	3:18										2	4	3	4	4	3	4	5	9	10	22	74:57
99	15	2:42						3	4	4	4	3	4	4	6	9	9	9	19	22	21	86	211:57
99	20	2:15			1	4	4	3	4	4	4	9	9	9	10	9	20	21	22	28	98	111	374:57
99	25	2:06		2	4	3	4	5	9	9	9	9	9	10	17	21	22	21	40	93	111	112	514:57
99	30	1:57	1	3	4	7	9	9	9	9	9	10	15	22	21	22	21	40	89	111	111	112	638:57
99	35	1:57	2	6	9	9	9	9	9	9	15	22	21	22	21	22	33	85	111	112	111	111	752:57
99	40	1:57	6	9	10	9	9	9	13	21	22	21	22	21	22	24	78	111	111	112	111	111	856:57

APPENDIX H

DIVE PROFILE COMPARISON

All Profiles Assume 60 FSW/min Ascent and Descent Rates.

Times at Depth Are Bottom Time and Include Descent Time From the Suface.

Times Are Either Min or Min:Sec.

Profile Numbers Refer to Table 1 or Table 2.

TABLE H-1

DIVE PROFILE COMPARISON

NO-DECOMPRESSION LIMITS

(Bottom Times in Decimal Minutes)

Depth FSW	HVAL 01	02	03	04	05	06	13	21
40	419.6	488.8	488.8	488.8	488.8	488.8	∞	722.7
60	128.6*	147.1*	147.1	147.1	147.1*	147.1	146.9	133.2
80	61.7	73.2	67.2*	67.2*	67.2*	61.5	67.0	51.5
100	36.0*	42.6*	36.0*	34.8	34.8*	32.6*	33.0	29.4
120	25.1	27.6	25.1*	22.3*	20.5*	19.5*	19.3	18.3
140	17.3	17.3*	17.3	16.0*	14.8	13.0	13.0	11.5
160	11.8*	11.8*	11.8*	11.3	10.7	9.7	9.7	8.8
180	9.3	9.3	9.3	9.0	8.6	7.9	7.9	7.3
200	7.9	7.9*	7.9*	7.6	7.3	6.8*	6.8	6.3

* No-decompression Limits Actually Tested

Controlling Tissue Halftimes (min)

40	160	160	160	160	200	160	---	120
60	80	120	80	80	80	80	80	120
80	40	40	40	40	40	20	40	20
100	20	20	20	20	20	20	10	20
120	20	10	20	10	10	10	10	10
140	5	5	5	10	5	5	5	5
160	5	5	5	5	5	5	5	5
180	5	5	5	5	5	5	5	5
200	5	5	5	5	5	5	5	5

TABLE H-2

DIVE PROFILE COMPARISON

Decompression Dives
(Depth/Bottom Time)

	HVAL	STOPS (FSW) 30	20	10	Total Decomp Time (min:sec)
	07			16	17:00
rofile #3	09			34	35:00
	11			20	21:00
60/170	12*			20	21:00
	13			20	21:00
	16			40	41:00
	21			40	41:00
	07			19	20:20
rofile #6	09			20	21:20
	11			23	24:20
80/90	12*			23	24:20
	13			23	24:20
	16			33	34:20
	21@			33	34:20
	07		1	54	56:20
rofile #7	09		1	70	72:20
	11		1	65	67:20
80/120	12*		1	65	67:20
	13		1	65	67:20
	16		11	75	87:20
	21		14	72	87:20
	07*		7	22	30:40
rofile #13	09*		7	22	30:40
	11		6	29	36:40
100/60	12		7	28	36:40
	13		7	28	36:40
	16		17	28	46:40
	21@		19	26	46:40
	07		29	49	79:40
rofile #14	09		29	59	89:40
	11		36	58	95:40
100/90	12*		36	58	95:40
	13		36	58	95:40
	16	7	39	61	108:40
	21	12	37	58	108:40

(Continued Next Page)

Dives actually tested.

Dives tested using air during decompression stops.
Profile 6 using air called Profile 45 in Table 2.
Profile 13 using air called Profile 46 in Table 2.

TABLE H-2
(Continued)

DIVE PROFILE COMPARISON

Decompression Dives
(Depth/Bottom Time)

		STOPS (FSW)						Total Decomp
	HVAL	60	50	40	30	20	10	Time (min:sec)
	07*				1	33	53	88:40
Profile #15	09				1	33	67	102:40
	11					41	64	106:40
100/95	12					41	64	106:40
	13					41	64	106:40
	16				10	41	70	122:40
	21				17	37	67	122:40
	07*				4	33	59	97:40
Profile #16	09				4	33	75	113:40
	11				4	41	71	117:40
100/100	12				4	41	71	117:40
	13				4	41	71	117:40
	16				15	41	79	136:40
	21				21	38	76	136:40
	07					13	17	32:00
Profile #21	09*					13	17	32:00
	11*					12	21	35:00
120/40	12*					15	23	40:00
	13*					15	23	40:00
	16*				1	24	23	50:00
	21				5	22	21	50:00
	07*			6	16	33	46	103:00
Profile #22	09			6	16	33	57	114:00
	11			3	23	41	55	124:00
120/75	12			4	24	39	55	124:00
	13			4	24	39	55	124:00
	16			14	24	39	61	140:00
	21			20	23	37	61	143:00
	07*		9	17	18	34	46	126:20
Profile #25	09		9	17	18	34	63	143:20
	11		8	20	25	41	53	149:20
140/65	12		9	24	24	37	55	151:20
	13		9	24	24	37	55	151:20
	16		19	24	24	23	47	137:20
	21	5	22	22	22	36	78	187:20

(Continued Next Page)

* Profiles actually tested.

TABLE H-2
(Continued)

DIVE PROFILE COMPARISON

Decompression Dives
(Depth/Bottom Time)

		STOPS (FSW)						Total Decomp
	HVAL	60	50	40	30	20	10	Time (min:sec)
	07			3	9	12	17	43:30
Profile #26	09*			3	9	12	17	43:30
	11			4	9	13	20	48:30
150/30	12			6	12	13	23	56:30
	13			4	10	16	24	56:30
	16			6	10	24	24	66:30
	21			9	11	22	22	66:30
	07*		7	17	17	19	34	96:30
Profile #27	09		7	17	17	19	43	105:30
	11		6	20	20	26	41	115:30
150/50	12		7	24	24	23	35	115:30
	13		7	24	24	23	35	115:30
	16		17	24	24	23	47	137:30
	21	3	22	22	22	21	53	145:30
	07*	1	17	16	17	34	49	136:30
Profile #28	09	1	17	16	17	34	66	153:30
	11		18	20	24	41	55	160:30
150/60	12		21	24	24	34	59	164:30
	13		21	24	24	34	59	164:30
	16	7	24	24	24	34	80	195:30
	21	17	22	22	22	34	86	205:30
	07			4	8	8	16	38:40
Profile #30	09			4	8	8	16	38:40
	11			4	9	10	17	42:40
160/25	12*			6	13	13	15	49:40
	13*			5	10	10	22	49:40
	16			6	11	16	24	59:40
	21			9	9	17	32	59:40
	07	3	16	17	17	23	38	116:40
Profile #31	09	3	16	17	17	23	55	133:40
	11	3	16	21	20	31	43	136:40
160/50	12*	5	18	24	24	23	47	143:40
	13	4	19	24	24	23	46	142:40
	16	9	24	24	24	23	68	174:40
	21	19	22	22	22	21	77	185:40

(Continued Next Page)

* Profiles actually tested.

TABLE H-2
(Continued)

DIVE PROFILE COMPARISON

Decompression Dives
(Depth/Bottom Time)

		STOPS (FSW)								Total Decomp
	HVAL	80	70	60	50	40	30	20	10	Time (min:sec)
	07				6	9	8	12	16	54:00
Profile #32	09				6	9	8	12	16	54:00
	11				7	9	10	12	21	62:00
180/25	12*				10	13	13	13	20	72:00
	13				8	10	10	17	24	72:00
	16			1	9	10	11	24	24	82:00
	21			4	9	9	13	22	22	82:00
	07		4	8	12	17	17	17	34	112:00
Profile #33	09		4	8	12	17	17	17	51	129:00
	11		4	10	12	20	21	20	43	133:00
180/40	12*		6	13	13	22	24	24	38	143:00
	13		5	10	15	24	24	24	35	140:00
	16		7	10	23	24	24	24	57	172:00
	21	3	9	14	22	22	22	22	68	185:00
	07*		6	11	17	16	17	23	53	146:00
Profile #34	09*		6	11	17	16	17	23	71	164:00
	11		7	10	20	21	20	31	61	173:00
180/45	12		10	13	21	24	23	24	66	184:00
	13		8	12	24	24	23	24	64	182:00
	16		9	21	24	24	23	24	87	215:00
	21	5	13	22	22	22	21	22	101	231:00
	07*						2	4	4	13:20
Profile #36	09						2	4	4	13:20
	11						2	4	4	13:20
200/10	12						4	6	7	20:20
	13						2	4	4	13:20
	16						4	4	4	15:20
	21					1	3	4	4	15:20
	07			3	4	9	8	8	14	49:20
Profile #37	09*			3	4	9	8	8	14	49:20
	11			3	5	9	9	10	16	55:20
200/20	12			6	7	11	13	13	13	66:20
	13			3	6	10	10	10	22	64:20
	16		11	4	6	10	10	17	23	74:30
	21		3	4	7	9	10	17	21	74:20
	07*		8	8	9	9	17	17	17	88:20
Profile #38	09		8	8	9	9	17	17	29	100:20
	11		9	9	9	11	20	20	23	104:20
200/30	12		12	13	13	13	17	24	24	119:20
	13		10	10	10	14	24	24	24	119:20
	16*	1	10	11	10	22	24	24	31	136:20
	21*	7	10	9	12	22	22	22	42	149:20

(Continued Next Page)

* Profiles Actually Tested.

TABLE H-2
(Continued)

DIVE PROFILE COMPARISON

Decompression Dives
(Depth/Bottom Time)

		STOPS (FSW)													Total Decomp Time
	HVAL	130	120	110	100	90	80	70	60	50	40	30	20	10	(min:sec)
	07						5	8	8	11	17	17	17	41	127:20
	09						5	8	8	11	17	17	17	58	144:20
	11						5	9	10	11	21	20	20	52	151:20
200/35	12						8	12	13	13	19	24	24	52	168:20
	13						6	10	10	15	24	24	24	45	161:20
	16						8	10	10	23	24	24	24	67	193:20
	21					4	10	9	15	21	22	22	22	81	209:20
	07									4	4	5	4	5	26:10
Profile #39	09									4	4	5	4	5	26:10
	11									4	4	5	4	8	29:10
250/10	12								1	7	6	7	7	7	39:10
	13*									4	4	5	4	10	31:10
	16								2	4	4	4	5	10	33:10
	21								4	4	3	4	5	9	33:10
	07			1	5	5	8	9	8	8	11	16	17	54	146:10
Profile #40	09			1	5	5	8	9	8	8	11	16	17	71	163:10
	11			1	5	6	9	10	9	9	14	20	20	68	175:10
250/25	12			3	7	7	13	13	13	12	13	16	24	88	213:10
	13*			1	5	8	10	10	10	10	19	24	24	62	187:10
	16			3	4	8	10	10	11	14	23	24	24	83	218:10
	21		3	4	6	9	9	10	9	18	21	22	22	102	239:10
	07			1	4	4	4	6	9	8	9	8	15	28	100:20
	09			1	4	4	4	6	9	8	9	8	15	41	113:20
	11			1	4	4	4	9	9	9	9	10	20	35	118:20
260/20	12			3	6	7	7	7	13	13	13	12	13	56	154:20
	13			1	4	4	5	10	10	10	10	15	24	27	124:20
	16			3	4	4	4	10	11	10	10	23	24	45	152:20
	21		3	3	4	4	7	10	9	9	13	22	22	58	168:20
	07			3	4	4	6	8	9	8	9	12	17	43	127:20
Profile #41	09			3	4	4	6	8	9	8	9	12	17	60	144:20
	11			3	4	4	8	9	9	10	9	17	20	54	151:20
260/22	12			5	7	7	8	12	13	13	13	12	19	79	192:20
	13			3	4	4	10	10	10	10	11	23	24	48	161:20
	16		1	4	4	4	10	10	10	10	19	23	24	70	193:20
	21*	1	3	4	4	7	9	9	9	9	22	22	22	84	210:20
	07		1	4	4	7	9	8	8	9	12	17	17	70	170:20
	09		1	4	4	7	9	8	8	9	12	17	17	87	187:20
	11		1	4	4	9	9	10	9	9	17	20	21	88	205:20
260/25	12		2	6	7	11	12	13	13	13	12	19	27	108	247:20
	13		1	4	5	10	10	10	10	10	24	24	24	81	217:20
	16		2	4	6	10	10	10	10	18	24	24	24	104	250:20
	21		4	4	9	10	9	9	9	22	22	22	32	113	271:20

* Profiles Actually Tested.

(Continued Next Page)

TABLE H-2
(Continued)

DIVE PROFILE COMPARISON

Decompression Dives
(Depth/Bottom Time)

		STOPS (FSW)															Total Decomp Time
	HVAL	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	(min:sec)
	07								2	4	5	4	4	4	5	9	42:00
Profile #42	09								2	4	5	4	4	4	5	9	42:00
	11								2	4	5	4	4	4	8	10	46:00
300/10	12*								5	6	7	7	6	7	6	13	62:00
	13								2	4	5	4	4	6	10	10	50:00
	16								4	4	4	4	5	5	10	13	54:00
	21							3	4	3	4	4	4	6	9	15	57:00
	07				1	4	4	4	4	4	5	7	9	8	9	25	89:00
Profile #43	09				1	4	4	4	4	4	5	7	9	8	9	33	97:00
	11				1	4	4	4	4	4	6	10	9	9	12	30	102:00
300/15	12				2	7	7	6	7	6	7	9	13	13	12	48	142:00
	13				1	4	4	4	4	4	9	10	10	11	17	24	107:00
	16				3	4	4	4	4	4	9	10	10	14	24	35	130:00
	21*			3	4	3	4	4	4	5	9	9	10	19	22	45	146:00
	07			2	4	5	4	4	4	7	9	8	9	8	19	55	143:00
Profile #47	09			2	4	5	4	4	4	7	9	8	9	8	19	72	160:00
(Air Stops)	11			2	4	5	4	4	5	10	9	9	9	13	23	69	171:00
300/18	12			5	6	7	6	7	7	9	13	13	12	13	22	101	226:00
	13			2	4	5	4	4	8	10	10	10	10	19	24	65	180:00
	16			4	4	4	4	4	9	10	10	10	14	24	24	84	210:00
	21*	1	4	3	4	4	4	5	10	9	9	9	22	22	22	101	234:00
	07		1	4	4	4	4	5	8	8	9	8	9	14	25	74	182:00
Profile #44	09		1	4	4	4	4	5	8	8	9	8	9	14	25	91	199:00
	11		1	4	4	4	4	7	9	9	10	9	9	21	30	93	219:00
300/20	12		2	7	7	6	7	6	11	13	13	13	13	12	49	112	276:00
	13*		1	4	4	4	4	10	10	10	10	10	15	24	24	97	180:00
	16		3	4	4	4	4	9	10	10	11	10	24	24	24	116	262:00
	21	4	3	4	4	3	8	9	9	10	9	18	22	22	47	112	285:00

* Profiles Actually Tested.

NOTE: Profile 47 only tested using air during decompression stops.
Profile 45 is Profile 6 using air during decompression.
Profile 46 is Profile 13 using air during decompression.

END

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